THE

RUBBER RESEARCH INSTITUTE

OF

MALAYA

IMPERIAL MYCOLOGICAL
7 DEC 1939
INSTITUTE

ANNUAL REPORT 1938

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THE RUBBER RESEARCH INSTITUTE OF MALAYA

MEMBERS OF THE BOARD

31st December 1938

The Director of the Institute (Mr. H. J. Page, M.B.E.—*on leave* Mr. C. E. T. Mann—*acting*)	Chairman, *ex officio*
The Hon'ble the Financial Secretary, F.M.S.	Financial Member (appointed by the High Commissioner under section 5 (i) (b) of the Enactment) (Cap. 108)
The Hon'ble the Director of Agriculture, S.S. and Adviser on Agriculture, Malay States	*Ex officio*
Che Hamzah, M.C.S., bin Abdullah Orang Kaya Kaya Stia Bi-jaya di-Rajah, Perak, (Che Mohamed Noordin, I.S.O., bin Jeragan Abdul Shukor)	appointed by the High Commissioner under section 5 (i) (d) of the Enactment (Cap. 108)
Mr. A. P. Cranna Mr. Choo Kia Peng, C.B.E., J.P. Mr. D. Farquharson, J.P. The Hon'ble Mr. B. J. R. Barton Mr. W. A. Wilken, M.C., J.P.	appointed by the High Commissioner under section 5 (i) (e) of the Enactment (Cap. 108)

The Permanent Committee

The Director of the Institute	Chairman, *ex officio*
The Hon'ble the Financial Secretary, F.M.S.	Financial Member, *ex officio*
Mr. A. P. Cranna Mr. Choo Kia Peng, C.B.E., J.P. Mr. W. A. Wilken, M.C., J.P.	appointed by the High Commissioner under section 13 (i)(c) of the Enactment (Cap. 108)

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REPORT OF THE BOARD

FOR THE

YEAR ENDED 31st DECEMBER, 1938

THE BOARD

The personnel of the Board at the 31st December, 1938, was

(a) The Acting Director of the Institute (*Chairman*)—

Mr. C. E. T. Mann

(b) The Acting Financial Secretary, F.M.S. (Financial Member)—

The Hon'ble Mr. H. R. Joynt, M.C.S.

(c) The Acting Director of Agriculture, S.S., and Adviser on Agriculture, Malay States—

The Hon'ble Mr. W. N. C. Belgrave

(d) Members representing the interests of small-holders—

Che Hamzah, M.C.S., bin Abdullah

Che Mohamed Noordin, I.S.O., bin Jeragan Abdul Shukor

(e) Members nominated by Planting Associations—

*Mr. A. P. Cranna

*Mr. Choo Kia Peng, C.B.E., J.P.

The Hon'ble Mr. B. J. R. Barton

Mr. D. Farquharson, J.P.

*Mr. W. A. Wilken, M.C., J.P.

Mr. H. R. Joynt was appointed to act as Financial Secretary, F.M.S., with effect from the 5th December, 1938. (*Gazette* notification no. 6028 of 9.12.38)

Mr. W. N. C. Belgrave was appointed to act as Adviser on Agriculture, Malay States, with effect from the 24th September, 1938, inclusive. (*Gazette* notification no. 4777 of 14.10.38)

Che Hamzah bin Abdullah was on leave for the period 8th June to 6th November, 1938, inclusive, and during his absence The Hon'ble Tuan Sheikh Ahmad bin Sheikh Mustapha was appointed a member of the Board (*Gazette* notification no. 3050 of 24.6.38).

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*These members served on the Permanent Committee.

Mr. A. P. Cranna returned from leave and resumed membership of the Board on the 10th February, 1938, and Mr. H. B. Egmont Hake, who had been acting for Mr. Cranna, retired from the Board.

Mr. B. J. R. Barton was on leave for the period 15th January to 14th August, 1938, inclusive, and during his absence Mr. R. Heywood was appointed to act on the Board (*Gazette* notification no. 355 of 21.1.38).

The death of Mr. J. Robertson occurred on the 24th September, 1938. Mr. Robertson was a member of the Board from the 25th September, 1937.

Mr. W. A. Wilken was appointed a member of the Board for a period of three years with effect from the 1st November, 1938, in place of the late Mr. Robertson (*Gazette* notification no. 5452 of 10.11.38).

Mr. H. J. Page, Director of the Institute and Chairman of the Board, went on leave from the 24th November, 1938. The High Commissioner appointed Mr. C. E. T. Mann to act as Director (*Gazette* notification no. 5772 of 2.12.38).

Meetings of the Board and Committees

During 1938 the Board held three meetings, the Permanent Committee five, and the Estimates (*ad hoc*) Committee one, a total of nine meetings.

Accounts for the Year 1938

Subjoined are the Income and Expenditure Account for the year 1938 and the Balance Sheet as at the 31st December, 1938.

The income for the year was—

Contributions from rubber-growers, through Administrations	$678,790 44
Interest on investments and bank balances ...	6,413 63
Sales of rubber and publications, etc. ...	62,320 96
	$ 747,525 03

Expenditure was—

Normal		$688,270 14
Special:		
Improvements to land on which Institute is built	$1,146 70	
Additions to Institute buildings	3,783 68	
Plant and Machinery	2,222 50	
Furniture for houses	45 00	
Furniture for laboratories and offices ...	2,931 55	
Experiment Station	20,833 30	30,962 73
		$719,232 87

From the balance sheet it can be seen that the total excess of assets over liabilities is $1,379,186.70 represented by:—

Buildings and Land ((Staff houses)		$286,918 18
Buildings and Land (Institute)		239,332 94
Land, other than the Experiment Station, for experimental purposes		8,430 98
Furniture (Staff houses)		19,023 33
Furniture (Institute)		16,264 22
Plant, Machinery and Apparatus		50,972 15
Experiment Station		490,999 70
Stocks		4,086 92
Sundry Debtors		39,131 19
Investments		163,012 12
Cash		163,769 49
		1,481,941 22
Less Sundry Creditors	$42,409 15	
Reserve for staff leave-pay and passages ...	53,715 23	
Rubber Roadways Committee—balance of grant from the Rubber Experimental Research and Propaganda Fund	6,630 14	102,754 52
		$1,379,186 70

The realisable investments (at cost) and available cash amount to $263,158.

Small-holders' Advisory Service

At the beginning of 1938 there were 24 Asiatic Rubber Instructors in the Service; during the year one died, and five were appointed, making a total of 28 at the 31st December, 1938.

During the year a Small-holders' Advisory Officer was appointed to visit the Instructors at their stations to supervise their work.

Activities of the Institute in 1938 and 1939

By the end of 1938 the planting of the experimental areas on estates in different parts of the Peninsula under the International Rubber Regulation Agreement was completed. In addition several experiments on estates have been commenced for the purpose of investigating tapping problems on old and young rubber trees. Other important investigations include work on the establishment of leguminous cover-plants with the aid of inoculation, and study of the life history of cockchafer grubs.

Dissemination of Information

A programme of lectures to planting organizations throughout the Peninsula was developed, and in July a conference of planters was held at the Institute.

A manual on the elementary principles of rubber-growing was compiled and published in English, Jawi and Chinese. A Tamil version will, it is expected, be produced early in 1939. The publication of *The R.R.I. Planters' Bulletin* and the printing of Advisory Circulars are other developments of the "extension" service.

C. E. T. MANN

Chairman of the Board

H. S. BLACKLIN

Secretary

Kuala Lumpur,

27th March, 1939

ACCOUNTS

INCOME AND EXPENDITURE ACCOUNT

Dr.

EXPENDITURE

	$	c.	$	c.
To Experiment Station			115,232	51
,, Board and Committees (Fees and Expenses) ...			1,607	53
,, London Advisory Committee			23,802	79
,, London Secretarial Expenses			7	50
,, Salaries and Allowances			274,994	21
,, Provident Fund			28,713	24
,, Staff Leave Pay and Passages			46,038	00
,, Medical			4,820	16
,, Travelling			24,790	13
,, Office General Charges (Printing, Stationery, Postage, Telephone, Audit and Legal) ...			8,774	13
,, Staff Recruiting			538	90
,, Rents, Rates and Insurance			4,279	57
,, Laboratory General Charges			1,609	23
,, Maintenance: Buildings (Offices and Residential Houses)			7,421	25
,, Maintenance: Laboratory Grounds			1,748	91
,, Laboratories and Offices Cleaning			474	99
,, Furniture and Office Equipment: Repairs and Renewals			3,467	07
,, Fixtures and Fittings: Repairs and Renewals			2,871	79
,, Plant and Machinery (Repairs and Running)			3,653	77
,, Power, Lighting, Water and Sanitation ...			10,590	48
,, Lorry (Running)			1,742	15
,, Workshop			657	75
,, Laboratory Apparatus and Glassware ...			9,866	46
,, Laboratory Chemicals			4,621	62
,, Publications issued by the Institute			10,949	50
,, Library (New Books, Subscriptions to Periodicals and Sundries)			5,387	81
,, Exhibitions and Demonstrations			452	24
,, Small-holders' Advisory Service:				
Film Propaganda	2,233	17		
Asiatic Rubber Instructors	50,318	70		
Experiments on Small-holdings	1,370	42		
Grant to Department of Agriculture for Vernacular Publications	2,000	00	55,922	29
,, Experiments (Field and Testing Laboratory)			33,234	16
,, Depreciation for year			76,999	28
			$765,269	42

KUALA LUMPUR,
13th February, 1939

FOR THE **YEAR** ENDED **31st DECEMBER, 1938**

Cr.

INCOME

		$	c.	$	c.
By	Contributions from Administrations for the year			678,790	44
„	Interest on Cash and Investments			6,413	63
„	Miscellaneous Receipts:				
	Sales of Rubber	58,268	83		
	Sales of Publications	1,418	75		
	Rents of Buildings	1,719	12		
	Proceeds of sale of old Electric Motor Generator $549 00				
	Sundries 365 26	914	26	62,320	96
„	Balance being Excess of Expenditure over Income for the year carried forward ...			17,744	39
				$765,269	42

(Sgd.) H. S. BLACKLIN
Secretary

(Sgd.) C. E. T. MANN
Chairman of the Board

BALANCE SHEET AS AT

LIABILITIES

			$ c.	$ c.
Sundry Creditors				43,324 66
Advance Receipts				500 00
Deposits for Publications				1,200 88
Reserves :				
Staff Leave Pay and Passages :				
Laboratory	$45,774 30			
Experiment Station	6,679 56		52,453 86	
Miscellaneous :				
Laboratory			1,261 37	53,715 23
Rubber Roadways Committee				6,630 14
Excess of Assets over Liabilities :				
Balance as at 1st January 1938			1,396,869 17	
Add Refund of Expenditure incurred in 1937 on Glasgow Exhibition			61 92	
			1,396,931 09	
Less Excess of Expenditure over Income for year			17,744 39	1,379,186 70
Carried forward ...				1,484,557 61

31st DECEMBER, 1938

ASSETS

			$ c.	$ c.
LAND AND BUILDINGS:				
132 Ampang Road				
Land as at 1.1.38			10,755 00	
Ampang Villa as at 1.1.38 ...		$12,187 98		
Less Depreciation for year ...		1,523 49	10,664 49	
132a Ampang Road Building				
As at 1.1.38		27,704 41		
Less Depreciation for year ...		3,463 02	24,241 39	45,660 88
Land behind Ampang Villa				
As at 1.1.38				5,029 35
5 Circular Road				
Land as at 1.1.38			17,147 08	
Old Building as at 1.1.38 ...		9,493 27		
Less Depreciation for year ...		1,186 66	8,306 61	
3 Houses as at 1.1.38		50,139 39		
Less Depreciation for year ..		6,267 42	43,871 97	69,325 66
163 Ampang Road				
Land as at 1.1.38			31,440 35	
Old Building as at 1.1.38 ...		8,815 32		
Less Depreciation for year ...		1,101 91	7,713 41	
5 Houses as at 1.1.38		59,095 33		
Less Depreciation for year ...		7,386 91	51,708 42	90,862 18
184/8 Ampang Road				
Land as at 1.1.38			27,582 50	
5 Houses as at 1.1.38		54,832 27		
Less Depreciation for year ...		6,374 66	48,457 61	76,040 11
Land on Ulu Klang Road ...				7,705 00
Land at Ampang Road under lease			829 69	
Less Amount written off			103 71	725 98
LABORATORY BUILDINGS & LAND (AMPANG ROAD)				
Land as at 1.1.38		21,843 98		
Add Cost of Improvements ...		1,146 70		
		22,990 68		
Less Amount written off		3,550 68	19,440 00	
Buildings as at 1.1.38		235,933 59		
Add Additions during year ...		3,783 68		
		239,717 27		
Less Depreciation for year ...		19,824 33	219,892 94	239,332 94
Carried forward ...				534,682 10

BALANCE SHEET AS AT

LIABILITIES—*(Contd.)*

	$ c.	$ c.
Brought forward ...		1,484,557 61
Carried forward ...		1,484,557 61

31st DECEMBER, 1938 *(Contd.)*

ASSETS—*(Contd.)*

		$ c.	$ c.
Brought forward ...			534,682 10
PLANT AND MACHINERY:			
Electric Plant as at 1.1.38	1 00		
Less Part Proceeds of Sale ...	1 00		
General Machinery as at 1.1.38 ...	26,401 50		
Add Additions during year ...	2,222 50		
	28,624 00		
Less Depreciation for year ...	4,293 60	24,330 40	24,330 40
FURNITURE:			
Residential Houses:			
As at 1.1.38	$21,092 03		
Add Additions during year ...	45 00		
	21,137 03		
Less Depreciation for year ...	2,113 70	19,023 33	
Offices:			
As at 1.1.38	6,955 27		
Add Additions during year ...	2,283 50		
	9,238 77		
Less Depreciation for year ...	923 88	8,314 89	
Laboratories:			
As at 1.1.38	7,319 58		
Add Additions during year ...	348 00		
	7,667 58		
Less Depreciation for year ...	766 76	6,900 82	
Library:			
As at 1.1.38	864 96		
Add Additions during year ...	300 05		
	1,165 01		
Less Depreciation for year ...	116 50	1,048 51	35,287 55
LABORATORY APPARATUS AND GLASSWARE:			
As at 1.1.38		34,037 83	
Deduct Sale during year		1,466 36	
		32,571 47	
Less Depreciation for year ...		6,514 29	26,057 18
MOTOR LORRY:			
As at 1.1.38		363 26	
Less Depreciation for year ...		90 81	272 45
WORKSHOP EQUIPMENT:			
As at 1.1.38		367 20	
Less Depreciation for year ...		55 08	312 12
Carried forward ...			620,941 80

BALANCE SHEET AS AT

LIABILITIES—(*Contd.*)

	$ c.	$ c.
Brought forward ...		1,484,557 61
Carried forward ...		$1,484,557 61

31st DECEMBER, 1938 *(Contd.)*

ASSETS—*(Contd.)*

			$ c.	$ c.
Brought forward ...				620,941 80
R.R.I. Experiment Station:				
Development Expenditure as at 1.1.38			481,508 27	
Add Additions during year ...			20,833 30	
			502,341 57	
Less Depreciation for year ...			11,341 87	490,999 70
Library Books and Periodicals:				
As at 1.1.38			1 00	
Add Purchases during year ...			3,141 49	
			3,142 49	
Less Amount written off			3,141 49	1 00
Stocks:				
Petrol and Oil:				
Laboratory		496 58		
Experiment Station		63 08	559 66	
Empty Drums and Containers:				
Laboratory		214 50		
Experiment Station		122 00	336 50	
Stationery			1,091 35	
Sundry Materials:				
Laboratory		$ 447 75		
Experiment Station		1,650 66	2,098 41	4,085 92
Sundry Deposits (For Water, Telephone etc.):				
Laboratory			235 00	
Experiment Station			20 00	255 00
Sundry Debtors:				
Administrations			1,300 00	
Staff			28,023 83	
Accrued Interest			650 00	
General			9,726 26	
At Experiment Station			109 62	39,809 71
Suspense:				
Laboratory			673 47	
Experiment Station			1,009 40	1,682 87
Investments at Cost:				
4½% Singapore Municipal Loan				
Nominal Value $15,000/- ...			17,536 69	
3½% British War Loan				
Nominal Value £17,000/- ...			145,475 43	163,012 12
Brought forward ...				1,320,788 12

BALANCE SHEET AS AT

LIABILITIES—(*Contd.*)

	$ c.	$ c.
Brought forward ...		1,484,557 61
		$1,484,557 61

I hereby certify that to the best of my knowledge and belief all

Kuala Lumpur,
13th February, 1939

We have audited the above Balance Sheet and Income and Expenditure
Malaya, and certify same to be correct according to the best of our information

Kuala Lumpur,
13th February, 1939

31st DECEMBER, 1938 *(Contd.)*

ASSETS—*(Contd.)*

			$ c.	$ c.
Brought forward ...				1,320,788 12
CASH AT BANK AND IN HAND:				
Chartered Bank, London			6,747 25	
Chartered Bank, Kuala Lumpur:				
Board's Account		92,181 21		
Rubber Roadways Committee ...		6,630 14		
Working Account		48,873 61		
Experiment Station		8,592 28	156,277 24	
Petty Cash:				
Secretary		137 90		
Imprest Advance		70 00		
Experiment Station		537 10	745 00	163,769 49
				$1,484,557 61

(Sgd.) C. E. T. MANN

Chairman of the Board

liabilities to 31st December, 1938, have been brought into account.

(Sgd.) H. S. BLACKLIN
Secretary

Account with the books and vouchers of the Rubber Research Institute of and the explanations given to us and as shown by the books of the Institute

(Sgd.) GIBSON, ANDERSON, BUTLER & CO.
Chartered Accountants
Auditors

ANNUAL REPORT

OF

THE DIRECTOR

Introduction

I left for England on long leave towards the end of November 1938. Mr. C. E. T. Mann, Head of the Botanical Division, was appointed by the High Commissioner to act as Director during my absence. Owing to the fact that the next senior officer of the Botanical Division was absent on long leave at the same time, the claims on the Acting Director's time were so onerous that the preparation of the Annual Report of the Director for 1938 was left until my return in July, 1939. This was also the more desirable since I had been on duty as Director for nearly eleven months of the year. The publication of the Annual Report of the Institute for 1938 is, for this reason, delayed some time beyond the normal date, the Annual Report of the Institute being intended to appear normally not later than the end of June.

In my report for 1937 I dealt fully with my so-called "two-year plan" for the development and expansion of the activities of the Institute, and my report was longer than usual by reason of the rather full explanation which I gave about the reasons for and the details of my proposals. I also gave a discussion of the field of work of the Institute and the basis of its distribution among the staff. It is not necessary to repeat these details here, but in order to obtain a clear idea of the developments and results recorded in this Report the reader should read it in conjunction with the relevant parts of my report for 1937.

The year 1938 was the second year of the plan. Later in this report, I deal with the developments which occurred during the year in partial fulfilment thereof. For the reasons explained above, and also because the Small-holders' Advisory Service now forms the subject of a separate report, my report this year is much shorter than that for 1937.

The complete fulfilment of the plan was, for various reasons, not practicable by the end of 1938, and certain matters, to which reference is made later in this report, were left over until 1939.

As stated in my report for 1937, the annual expenditure of the Institute was expected to be relatively stable after the completion of the developments there announced, but it would be at a level which would exceed the statutory maximum income, derived from a cess of 10 cents per pikul of rubber exported, if the

average export release for the year under the International Rubber Regulation Agreement fell below about 67 per cent. The average release for 1938 did in fact fall below that figure, being 55 per cent. However, the contributions from the Malayan Rubber Fund were paid for 1938 at the rates already agreed on the basis of the Estimates for that year, approved late in 1937, so that the income of the Institute for 1938 was adequate for requirements in spite of the low export release.

It is a very unsatisfactory arrangement for the income of a scientific institution of this kind, the work and staffing of which must be planned on a settled basis, to be liable to variation within wide limits at the caprice of the world rubber market. I therefore recommended the Board to suggest to the Controller of Rubber—as administrator of the Malayan Rubber Fund,—that the income of the Institute might be stabilised by the calculation of the contribution from that fund on the basis of the Malayan Basic Quota instead of on annual exports. This recommendation was accepted by the Board, and the Controller of Rubber was approached accordingly. Although notification of the decision reached in this matter was not received before the end of 1938, it is recorded here that the suggestion has been accepted and that a satisfactory and stable basis of income as determined by the contributions from the Malayan Rubber Fund has now been established, so long as International Rubber Regulation is in force. Further details of this will be given in the 1939 report.

Staff

There were two additions to the European staff; one by the appointment of a Small holders' Advisory Officer (a new post), to supervise the work of the Small-holders' Advisory Service, (See Annual Report for 1937, p. 16); and the other by the appointment of a chemist to fill the vacancy which occurred in the Chemical Division in 1937. The appointment of a Publications and Information Officer, also approved in 1937, was deferred.

Three Research Officers left the Institute during the year to take up other appointments. Two of these, the Head of the Chemical Division, (who left in September), and the next senior Chemist in that Division, (who left in December), were appointed to the staff of the British Rubber Producers' Research Association (B.R.P.R.A.) which was formed in 1937 and started to build up its staff in 1938. The loss of these two officers caused a serious gap in the staff of the Chemical Division, but it was the obvious duty of this Institute to assist in the staffing of its new sister organisation. The transfer to it of two of the Institute's senior officers, which was made by arrangement with the Director of

Research of the B.R.P.R.A., will, it is hoped, help to facilitate the close co-operation between the two organisations which is so necessary. One of the reasons for my going on leave sooner than was originally intended was so that I could assist in the recruitment of men to fill these vacancies in the Chemical Division.

The third officer to leave the service of the Institute (in August) was a Soils Chemist, who accepted an appointment at his old University. An appointment to fill the vacancy so created in the Soils Division was made in the latter part of the year, the officer appointed being due to take up his post early in January 1939.

The Manager of the Experiment Station submitted his resignation in December, in order to accept an appointment as a visiting agent to one of the chief agency houses in Malaya. The date for his relinquishment of his duties was 1st June, 1939.

The post of Head of the Pathological Division, which had remained in abeyance since 1934, was resuscitated in January, when one of the Pathologists in that Division was given the post.

European officers on long leave during the year were the Assistant Manager of the Experiment Station (April to October inclusive), and the senior Botanist (from November inclusive), in addition to myself (from December inclusive). A temporary assistant was engaged during the absence of the Assistant Manager of the Experiment Station.

Details of the above staff matters are shown in an appendix to this report.

Five new Asiatic Rubber Instructors were engaged during the year, in accordance with the intended expansion of the Smallholders' Advisory Service during the years 1938-42. One Asiatic Rubber Instructor and one Laboratory Assistant died during the year, and one Laboratory Assistant left on retirement. The number of Junior Staff at the end of the year, including 27 Asiatic Rubber Instructors, but excluding men on daily rates of pay, was 160.

The Institute also contributed towards the wages of several conductors employed by estates in connection with experiments carried out for the Institute; the wages and expenses of the Asiatic Rubber Demonstrators employed by Asiatic Rubber Instructors were also paid by the Institute.

The number of men employed on daily rates of pay, on 31st December, 1938, was 35 at headquarters (including small-holdings at Ulu Klang and Ampang Road) and 262 at the Experiment Station.

The total number of employees of all grades, at the end of the year, was thus 476.

The Staff Committee (see Annual Report, 1937, p. 17) held 10 meetings during the year, and proved of much assistance to me.

Relative amounts of Research and Advisory Work

In my report last year I gave, for the first time, data showing the proportions of the time of the graduate staff which were devoted to research and to advisory work, based upon their daily "logs." Corresponding figures have been worked out for 1938. They are shown, together with those for 1937 for comparison, in the following table. The 1938 figures for the Institute as a whole are similar to those for 1937, with a slight increase in the proportion of the time devoted to research: taking all graduate officers,

Relative amounts of time spent on Research and on Advisory work by the Scientific Staff of the Institute in 1937 and 1938

Division	Average number of Scientific Staff*		Percentage of time devoted to Research & Experimental Work		Advisory Work	
	1937	1938	1937	1938	1937	1938
Botanical						
All scientific officers -	$5\frac{6}{12}$	$6\frac{10}{12}$	80	**85**	20	**15**
Research officers only -	$3\frac{6}{12}$	$4\frac{10}{12}$	69	**78**	31	**22**
Chemical						
All scientific officers -	$4\frac{9}{12}$	$5\frac{4}{12}$	64	**74**	36	**26**
Research officers only -	$3\frac{9}{12}$	$4\frac{4}{12}$	63	**77**	37	**23**
Pathological						
All scientific officers -	3	3	63	**64**	37	**36**
Research officers only -	2	2	47	**47**	53	**53**
Soils Division						
All scientific officers -	$3\frac{8}{12}$	$3\frac{8}{12}$	62	**52**	38	48
Research officers only -	$2\frac{8}{12}$	$2\frac{8}{12}$	50	**35**	50	**65**
Whole Institute						
All scientific officers -	$19\frac{6}{12}$	$22\frac{5}{12}$	67	**69**	33	**31**
Research officers only -	$14\frac{6}{12}$	$17\frac{5}{12}$	57	**63**	43	**37**

*This is expressed in man-years, e.g. $22\frac{5}{12}$ means the equivalent of 22 men each for the whole year and one man for 5 months.

the proportion in 1938 was slightly over two-thirds, and for Research Officers only it was slightly under two-thirds. This results from the increases in staff which occurred, being as an average for the year nearly the equivalent of three officers. Provided that the amount of advisory work does not increase proportionately to the increase in staff, the result of such increase is to allow a greater proportion of the time of the staff to be devoted to research. This is borne out by the figures for the Botanical and Chemical Divisions, in which an increase in staff is accompanied by a definite increase in the proportion of time given to research; and for the Pathological Division, where there was no change either in the number of staff or in the division of time between research and advisory work. In the Soils Division, however, a slight increase in staff was accompanied by a decrease in the proportion of time given to research. This was the result of special circumstances which are further discussed later in this report.

It was pointed out last year that the establishment of a criterion regarding the proper proportions of time to be devoted to research and advisory work must depend upon the actual circumstances of the Institute and the industry. From the fairly close similarity between the figures for 1937 and 1938, it seems likely that after one more year's figures have been obtained, a more detailed analysis will be worth while, as a means of ascertaining whether there is a good case for any changes in the orientation of the work of scientific officers as between research and advisory work, on the lines adumbrated in my report for 1937 (p. 21).

Advisory Work—General

Extension Work

The chief developments on the advisory side, foreshadowed in the 1937 report, were in connection with the Institute's "extension" work, *i.e.* its activities on behalf of the whole industry and not merely in response to specific requests for advice from individual estates.

This extension work is effected by the spoken and the printed word. For the former, the chief means are lectures and conferences.

The improved arrangements for lectures which were introduced in 1937 (Annual Report for 1937, pp. 24 and 30) were continued and developed in 1938. The total number of lectures given, and their distribution among Divisions and among States and Settlements, are shown in the following table:—

Lectures given by Research Officers in 1938

State or Settlement	Division					
	Botanical	Chemical	Pathological	Soils	Experiment Station	Total
Perak ...	2½	3	2½	2	1	11
Selangor ...	2	1	4	2	2	11
Negri Sembilan ...	1½	—	½	—	2	4
Pahang ...	—	—	—	3*	1	4
Johore ...	3	2	1	—	—	6
Kedah ...	1	1	—	1	1	3
Kelantan ...	1	—	—	—	—	1
Malacca ...	—	—	1	—	—	1
Penang & P.W.	1	—	—	1	—	2
Total ...	12	7	9	9*	6	43
Rate per Officer	2.5	1.6	4.5	3	2.4	2.9

*This includes a lecture by the Director.

In addition to the above, I gave a lecture at Beaufort, State of North Borneo, in August. Several members of the staff attended the Annual Conference of the Incorporated Society of Planters at Penang in September, and read papers. These are not included in the above figures.

Comparison of these figures with those for the previous year (Annual Report, 1937, p. 30) shows that nearly three times as many lectures were given and that their distribution among the Divisions was less uneven. The distribution among the different States and Settlements was also more nearly in accordance with their relative planted acreages of estates than hitherto. Lectures are arranged with the local branches of the Incorporated Society of Planters and with District Planters' Associations. In the year's lecture programme an equal number of lectures was allocated to each of the areas covered separately or jointly by these bodies. Inequalities in the actual distribution may be caused both by variations in the planted areas represented by these bodies, and by varying degrees of response by them to the Institute's offer of lectures.

The first of the new R.R.I. "Planters' Conferences" was held at the end of July. This was devoted to the subject of "The Role of Cover Plants in Rubber Growing." The arrangements for the Conference were a new departure, for Malaya. A general invitation was issued to all planters to submit papers, but acceptance depended on relevancy, length, and avoidance of duplication. Special invitations were also issued to selected individuals to submit papers on named subjects on which they were known to be experts or to hold pronounced, and sometimes perhaps unorthodox, views. Papers were also prepared by officers of the Institute. In this way a comprehensive and balanced programme was built up. All papers were printed and published two weeks before the date of the Conference. I wish to express to the Incorporated Society of Planters my special thanks for their help by publishing the papers in the form of a special issue of *The Planter*.

The papers were classified into groups viz: Establishment Control and Maintenance of Covers (a) in Young Areas (b) in Mature areas; The Effects of Covers (a) on Growth and Yield of Rubber, (b) on the Soil; Pests and Diseases. Before the conference, a digest of the papers in each Group was prepared by a member of the Institute staff. These digests, together with certain other papers received since the publication of the main body, were printed, and issued to those attending the Conference on their arrival. The papers in each Group were not separately presented to the meeting by their writers, but the discussion consisted, for each Group in turn, first of the reading of the digest by the officer who had prepared it, then a discussion open only to those who had not submitted papers in the Group, and finally a general discussion including the writers of the papers under discussion. In this way the proceedings were arranged in an orderly and well-balanced fashion, with adequate time for all aspects, and with a means of stimulating and leading the discussion on relevant lines. We were fortunate to secure the active co-operation of the Adviser on Agriculture, Malay States, who took the chair, of the United Planting Association of Malaya, whose President opened the proceedings, and of the Incorporated Society of Planters, whose Chairman acted as Vice-Chairman of the Conference.

The attendance at the Conference was gratifyingly large, in fact the accommodation in the Institute's Conference Room was crowded out, and many intending participants, some from considerable distances, could not get in. This response was a clear indication that this new departure had the active approval of the planting community and an encouragement for the arrangement of further such conferences in the future.

Officers of the Institute took a prominent part in the Annual Conference of the Incorporated Society of Planters at Penang in September, one session of which, on "New Planting," was arranged on similar lines to the R.R.I. Conference just described.

The chief development in the other side of the Institute's extension work—its publications—was to be the so-called Monthly Newsletter (see Annual Report, 1937, p. 24). This was renamed before publication, as the *R.R.I. Planters' Bulletin*, and preparations for its inauguration were complete at the end of the year, though its first number did not actually appear until early in 1939.

Two issues of the Institute's Journal were made, Vol. 8, No. 2 in January and Vol. 8, No. 3 in November. Planting Manual No. 7 (Small-holders' Advisory Service, Publication No.1; see Annual Report, 1937, p. 39), entitled "Rubber Growing, Elementary Principles and Practice," was published in English, in January, whilst Malay and Chinese editions were published later in the year and a Tamil edition was in preparation for publication early in 1939. The preparation of these vernacular translations, and their distribution, were much facilitated by the valuable co-operation of the Department of Agriculture, with their publication in the form of separate numbers of the respective vernacular Journals of that Department.

The Annual Report for 1937 was published in July, 1938.

An interesting new development was the publication in "Ameasan," the organ of the All-Malayan Estate Asiatic Staffs' Association of articles written by Asiatic Graduate Assistants on the staff of the Institute. This is a valuable way of enabling the Asiatic staff of estates to learn more about the Institute's work.

Small-holders' Advisory Service

With the further development of this service, and the appointment of a full-time Small-holders' Advisory Officer to supervise its work, a separate report on the work of the Service in 1938 is now published (see page 192), instead of including it in my report as hitherto (see Annual Report 1937, p. 31).

Noteworthy features in the report are: the particulars of distribution of the Asiatic Rubber Instructors (page 193) showing that the average area of small-holdings per instructor is about 50,000 acres; the innovation of the appointment of Asiatic Rubber Demonstrators to assist the Instructors (page 194) which promises to add considerably to the efficiency of their work; the bark survey on small-holdings, which is a development, with the aid of recent statistical methods, from a survey carried out in the Department of Agriculture in 1931/32; the preparations for new planting and replanting on small-holdings (page 199) and the

arrangements for the supply of high-yielding planting material therefor; and the problem of helping the small-holder to get a better price for his produce, commensurate with the improved quality that he can now turn out as a result of the activities of the Small-holders' Advisory Service.

The last-mentioned problem is a difficult one. It is clear that real progress cannot be expected if reliance is placed mainly on the willing co-operation of the small dealers, and that the problem must also be tackled from the top: the co-operation of the large dealers and exporters must be sought, and schemes of co-operative bulk selling must be studied. The active collaboration of the Co-operative Societies Department, S.S. & F.M.S., in this matter is much appreciated.

Advisory Work: Estates

Divisions were more nearly at full strength in 1938: as compared with a cadre of 20 graduate officers in the four Divisions the average strength for the year was 18 10/12, or 94%, the deficit of 6% being of course the result of absences on leave and the staff changes referred to earlier in this report.

The additional officers appointed in 1937 so as to reinforce the advisory side of the work of Divisions (see Annual Report, 1937, p.p. 21 and 68) were on duty throughout the year, and as a result it was found possible to give prompt attention to requests for advice.

The following table includes a summary of the advisory work of Divisions in 1938, though also included in these figures are visits, correspondence and interviews relating to experiments on estates as well as to specific advisory work. The figures in brackets are the corresponding data for 1937 (see Annual Report, 1937, p. 30).

The distribution of the tours of visits was Johore 10, Negri Sembilan and Malacca 7, Selangor and Pahang 3, Perak 18, Province Wellesley and Kedah 24, Kelantan and Trengganu 2. Included in this distribution, but not in the Table, are two tours by the Director. I also made tours in Brunei (3 estates) and North Borneo (9 estates) and visited one estate in Sarawak. My total number of estate visits (not included in the Table) was 26. My visit to Brunei and Labuan was primarily to study conditions on small-holdings in those territories, and I wish to record my thanks to the various officials who helped to make my visits instructive and enjoyable, and especially to the Agricultural Officer, Brunei and Labuan. The Statistician also visited 26 estates not included in the Table.

The tours of visits to small-holdings by the Small-holders' Advisory Officer and by my Personal Assistant are not included

	Division				
	Botanical	Chemical	Pathological	Soils	Total
Visits to estates (excluding experimental Station) ...	553 (*178*)	99 (*121*)	117 (*83*)	267 (*262*)	1036 (*644*)
Interviews at the Institute ...	203 (*174*)	368 (*349*)	124 (*91*)	189 (*145*)	884 (*759*)
Letters Received ...	2558 (*1737*)	889 (*927*)	1444 (*1508*)	1577 (*1330*)	6468 (*5502*)
Letters Sent ...	3481 (*1949*)	1425 (*1162*)	1897 (*1435*)	1978 (*1763*)	8405 (*6309*)
Specimens and Samples received for examination and/or analysis ...	377 (*137*)	670 (*595*)	529 (*764*)	2119 (*1090*)	3695 (*2586*)
Tours of visits ...	13 (*11*)	21 (*14*)	10 (*5*)	18 (*23*)	62 (*53*)
Visits and Interviews and Letters received, per working day* per Research Officer ...	3.3	1.1	3.0	2.7	2.2

*Reckoning a Saturday as 2/3rds of a full working day.

in the above statements, being dealt with separately in the Smallholders' Advisory Officer's report (page 192).

The Table shows that in comparison with 1937 there has been an increase under all categories, the most marked increase being in numbers of visits, in the number of letters sent, and in the number of specimens and samples examined. The increases in number of visits and in number of letters sent occurred mainly in the Botanical Division, and are partly a reflection of the fact that the increase in staff as compared with 1937 was greatest in that Division.

The figures in the bottom line of the table show roughly the relative incidence of the main forms of advisory work (visits,

interviews and letters) per head of the staff, in numbers, but not in time. The value for the Chemical Division is much lower than those for other Divisions because the latter include many visits in connection with experimental work whilst the Chemical Division visits are chiefly advisory.

In addition to the letters dealt with in Divisions, over 5,000 letters were received and dealt with in the offices of the Director, the Secretary, the Statistician and the Small-holdings' Advisory Officer.

Stencilled "circulars" were prepared in Divisions for issue in reply to enquiries from Estates, in the case of many of the common subjects of enquiry.

Reference to the analyses of Divisional correspondence, which form appendices to this report, indicates the subjects on which advice was sought, and their relative incidence.

In general, the chief subjects of enquiry in all Divisions were similar to those in the previous year (Annual Report, 1937, p. 31). The most marked increases occurred in connection with new planting and replanting (see pages 40 and 43), planting operations, choice of clones and clone records (see page 40); fertilisers and soil samples (see page 43); cultures of nodule bacteria for leguminous cover plants (see page 44); smoked sheet (see page 42).

The increased number of enquiries about new planting and replanting, and choice of clones, resulted largely from the announcement of the terms of the new International Rubber Regulation Agreement, whereby a limited amount of new planting, and unrestricted replanting, are allowed after 1938.

The number of enquiries and reports about the cockchafer grub pest showed a notable increase; moreover, during recent years the incidence of minor insect pests on rubber estates has shown a steady increase—simultaneously with and possibly in association with the more general cultivation of cover plants. Thus the numbers of insect specimens sent in for identification and advice were about 10 per annum for 1933-1935, 25 in 1936, 94 in 1937, and 113 in 1938. The number of letters received regarding insect pests (excluding replies to the cockchafer questionnaire in 1937) were about 55 per annum in 1933-35, 107 in 1936, 240 in 1937 and 460 in 1938. These facts were mainly responsible for the decision to appoint an Entomologist to the staff of the Institute (see page 34). Hitherto the Senior Entomologist, in the Department of Agriculture, has undertaken identifications for us and has been available in a consultative capacity, but apart from other considerations it was clear that the volume of work was becoming more than he could be expected to undertake. I wish to take this opportunity of expressing appreciation and thanks for the help so freely given in the past.

Research and Experimental Work: General

In my report for 1937, under this heading, I dealt rather fully with the principles underlying the structure of the research programme of the Institute, and with the scope of work of the Divisions (Annual Report, 1937, p.p. 40-45). The considerations there propounded apply continuously, and will not be restated here. That section of my report for 1937 should, however, be re-read as an introduction to the perusal of those parts of the Annual Report of the Institute for 1938 which deal with research and experimental work.

The Statistics Section was inaugurated late in 1937, and soon after the beginning of 1938 it was getting well into its stride, and able to furnish Research Officers with the guidance and assistance which it was established to provide. The following report on its work is taken from a report furnished by the Statistician.

The outcome of nearly all the work of the Statistics Section becomes incorporated in the work of the Divisions, and the measure of its practical value is to be found mainly in an increased efficiency of the work in these quarters.

Design of Experiments

The number of experiments on the design of which the Section has been consulted is approximately equal to the total number of experiments which have been initiated by the Soils, Botanical and Pathological Divisions since November, 1937, and by estates in collaboration with these Divisions. The work involved has varied from a matter of minutes for a simple 16-plot experiment, to two days which were taken to devise a double "quasi-latin-square" for a 7-factor (128 plot) experiment.

A certain amount of advice on design and interpretation of experiments has been given also to outside interests.

Factorial designs have been introduced wherever possible. Owing to the efficiency of this type of experiment, our experiments planned or re-organised on this principle should yield at least three times more information per plot than comparable experiments in the Institute's earlier work. It should be noted here that for a number of simpler experiments the Soils Division had already adopted factorial designs and that the methods of extending the principle to complex experiments is a development only of the last five years.

Analysis of Experimental Results

Data have been analysed and reports made along more or less routine lines, for about 65 experiments. The work involved may vary from about an hour for a simple analysis of variance for a small experiment, to several days for the more complicated analyses

of covariance and of complex experiments with large numbers of observations.

The following special investigations account for several weeks of the Section's time:

1. To determine a relationship between viscosity and d.r.c. of latex
2. Sampling investigations to estimate
   (a) number of trees per plot which should be measured
   (b) permissible ways to take samples.
3. To study accumulated data from Block 6 Manurial Experiment at the Experiment Station.

Preliminary work on the Block 6 figures has led to certain tentative conclusions which will form the hypothesis on which a more thorough analysis of these and other data can be based. Meantime work on this subject has been postponed pending acquisition by the Institute of automatic computing machinery. Final evaluation of these data is likely to involve some research in mathematical statistics on the subject of "transformations."

The ease and speed with which the Section can analyse data received is extremely dependent on the efficiency of the original design of an experiment and the care with which it has been carried out. The results from a well-designed and managed experiment can be quickly and easily worked out by a computer with a minimum of supervision. When designs do not follow standard lines; when effects, either of treatments or of incidental circumstances such as swamps and times of planting, are not orthogonal; when records from some plots are missing or unreliable etc.; all such cases require personal attention to devise a suitable method for evaluating the results, and special instructions to computers sometimes requiring hours for illustration and explanation. As a small example: the straight-forward analysis of variance of one of the Experimental Planting phosphate experiments requires about 2—3 hours. One of these gave an estimate of error so high that the results were almost useless. Eventually it was discovered that some plants fell on swamps, and that planting material had been uneven. When allowance was made for these features this experiment fell into line with the rest, but computing labour alone took two days.

Co-operation with other cognate Research Organisations has continued on the same lines as stated in the Annual Report for 1937 (p. 45).

In September, Mr. C. E. T. Mann, the Head of the Botanical Division, made a tour of rubber research institutions in Java. In April Mr. J. H. Piddlesden, of the Chemical Division, visited a number of estates and firms in Indo-China.

The co-operation between the Chemical Division of the Institute and the scientific staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya) is much facilitated if members of that staff have some personal acquaintance with the work of the Institute and with conditions in the rubber-growing industry in the East. To this end, Mr. W. S. Davey, a member of that staff, visited Malaya during the year. Besides spending some time at the Institute, he made extensive tours in Malaya, Java and Sumatra, and visited the Ceylon Rubber Research Scheme.

The visit to Malaya of Mr. J. Wilson, Director of Research of the newly-formed British Rubber Producers' Research Association (B.R.P.R.A.), (under the auspices of the International Rubber Research Board of the International Rubber Regulation Committee), extended into 1938, and afforded opportunities for him to become acquainted with the staff and work of the Institute and for possible lines of co-operation between the Association and the Institute to be envisaged. The active establishment and staffing of the B.R.P.R.A. following Mr. Wilson's return to England in March raised a number of questions concerning the co-ordination of the work of the new organisation with that of the scientific staff of the London Advisory Committee for Rubber Research, which is maintained jointly by this Institute and the Rubber Research Scheme of Ceylon. It was desirable that these questions should be dealt with by personal negotiation, and in view of the need for their early solution, I proceeded home on long leave in November, several months sooner than previously planned.

The need for closer co-operation among, and co-ordination of the work of, the rubber research organisations in the East, to which reference was made in my 1937 report (p. 46), was the subject of preliminary discussion between the institutions concerned, and it is hoped that a definite scheme will result in 1939.

Experimental Planting

All experimental planting under the 1934-38 International Rubber Regulation Agreement had to be completed by the end of 1938. Of the 8,177 acres allowed to Malaya under this scheme, all but 64 acres was actually planted by that time. The total number of experiments is 145, situated on 87 estates, and their distribution throughout Malaya in shown in the following Table (see next page):—

The subjects of these experiments are covered by the classification shown on p. 38 of the Annual Report for 1936. Particulars of many of them are to be found in the present Reports of the Soils and Botanical Divisions. A more detailed analysis and classi-

fication of the experiments will appear in the Annual Report for 1939.

Experimental Planting
Numbers of Estates and Experiments

State	Estates	Experiments
Selangor ...	19	40
Negri Sembilan ...	17	22
Perak ...	10	17
Pahang ...	4	9
Kedah ...	8	15
Johore ...	22	40
Kelantan ...	2	4
Trengganu ...	1	2
S.S. & Brunei ...	4	6

Note: The above table excludes the R.R.I. Experiment Station and small areas assigned for nurseries etc.

Soils Problems

A detailed discussion of the nature of the problems within the scope of the Soils Division will be found on pages 47—50 of my report for 1937. The report of that Division for 1938 records steady progress in most sections of its work. However, the progress attained in 1938, following the full staffing of the Division in 1937, and the catching-up of arrears of analytical work following the fire in 1936, was somewhat less than had been hoped for, particularly for the soil survey work, owing to the unexpected departure of Mr. Hamilton to take up another appointment. Fortunately the vacancy was soon filled, so that the set-back on this account was not a serious one.

The progressive growth in the body of data accruing from manuring experiments, and the considerable additions to the programme of such experiments, have been accompanied by a marked increase in the interest in commercial manuring on estates, which is now coming to be regarded as a standard feature of estate practice.

The introduction of sampling methods of recording yields for experiments is expected to increase the reliability of the results, and to make possible the simplification of the design and conduct

of the experiments in some respects. More work is however still needed to ascertain the best sampling technique (see pages 28 and 49).

Experiments on the manner of use of manures (rate, frequency, time, and method of application) have been started, and may be expected to yield valuable information for both mature and young rubber trees (see pages 48, 52 and 53).

For young replanted rubber, the results so far available indicate no superiority of expensive organic manures of the animal refuse type over inorganic manures (see page 51).

Bulky organic manures, such as compost, cattle manure, however, are of real value, but owing to scarcity of raw material in relation to the very heavy dressings needed, their use is scarcely a practical proposition except in the nursery and in the planting hole (see page 52).

Mulching with plant refuse (weeding, loppings, etc.) is also of value, especially for the conservation of moisture in the surface soil. This is of particular importance for young seedlings and stumps with only rudimentary root systems. In this connection many experiments and observations have emphasized the great importance of planting early in the wet season so that the root system may have the greatest chance of developing well before the surface soil is liable to dry out (see page 51).

Work is still in progress in the study of the factors concerned in the successful establishment of leguminous cover plants under shade, but much remains to be done before a solution of the problem is in sight (see page 54).

The retarding effect of covers on the growth of young rubber plants is a result of root competition, and results of experiments appear to indicate that it is mainly a question of competition for moisture, not plant food (see page 55).

A number of experiments on methods of planting and clearing are in progress, but in most cases conclusive results from these cannot be expected for several years. Definite indications of improved growth have however been obtained from an experiment on the use of dynamite for breaking laterite "hardpan" before planting (page 52).

Laboratory and pot-culture work on the phosphate status of soils, on leaf analysis, and on the nitrogen economy of soils as affected by leguminous cover plants, was in progress during the year (see pages 56 and 57).

The allocation of work amongst the graduate staff of the Soils Division remained as shown on page 52 of the report for 1937. The percentages of time devoted to research and advisory work respectively, in 1937 and 1938 are:—

	Research		Advisory	
	1937	1938	1937	1938
Mr. C. G. Akhurst ...	39	41	61	59
Mr. R. A. Hamilton ...	66	70	34	30
Dr. A. W. J. Dyck ...	28	8	72	92
Mr. K. S. Pillai ...	90	90	10	10

The only marked difference between the two years is in the case of Dr. Dyck. His figures for 1937 were based upon only three months (he joined on 7th October, 1937) during which he devoted over a quarter of his time to work in connection with experiments, in the course of familiarising himself with the work of the Division and with Malayan rubber-soil problems. In 1938 the volume of advisory work handled by the Division increased markedly (see page 57) and most of this increase fell on his shoulders, almost to the exclusion of experimental work. It is intended to modify the allocation of work so as to allow a somewhat larger proportion of his time for research.

Botanical Problems

The nature of the problems within the field of the Botanical Division, their relative importance, and their allocation among the staff of the Division, were fully set forth in my report last year (Annual Report, 1937, pages 53-55). There was a slight alteration in the allocation in 1938 (see page 59).

With the Division at full strength and with all officers on duty for almost the whole of the year, the report on the work of the Division is more than usually comprehensive this year.

The work on the use of growth-promoting substances ("hormones") has given results of much potential practical importance in connection with budded-stump plantings (see page 61; also *Planters' Bulletin* No. 4).

The work on stocks is yielding valuable information on the characteristics of the root system, but so far there is little evidence of much effect of stock characteristics on the growth or yield of the scion, or *vice versa* (see pages 62—67).

The records of yields of proved clones are enabling the order of merit of the recommended clones to be stated with much

confidence. Data for yields under commercial tapping are now being collected; these will add considerably to our knowledge of the performance of different clones, particularly in relation to varying soil and climatic conditions (see pages 67—72).

The greatly enlarged scheme of tapping experiments was successfully inaugurated during the year, (see pages 72—90). The tapping experiments already in progress at the Experiment Station have yielded results of considerable interest. The full-spiral system, with tapping every fourth day, is showing up well (pages 74 and 80). Daily alternate-monthly tapping, though giving promising results in early years, may do so at the expense of the growth of the trees; but the data are not yet conclusive (page 78). In the study of tapping systems for budded rubber trees, the idiosyncrasies of different clones must be kept well in mind. It seems that systems such as full-spiral fourth-daily, or half-spiral daily alternate-monthly, which are inferior to the standard half-spiral alternate-daily with some clones, may be markedly better with others (pages 79 and 81). Clones also vary in regard to the influence of height of tapping on yield (page 87). Generally speaking half-spiral alternate-daily tapping without rest does not appear to be too severe a system for budded trees in good health, and is therefore to be preferred to periodic systems such as A.B.C. if the maximum economic crop is wanted.

The work on selection and breeding indicates that new clones with higher yields than the best of those now available for commercial planting are likely to be obtainable only as a result of breeding work, and not by further selection from estate trees. The R.R.I. 500 series of clones, resulting from the breeding work in 1928-31, continue to show great promise (page 97). Some of the seedlings from the Tjikadoe Isolated Seed Gardens are also giving comparable yields (page 99). But the variability among "clonal seedling" trees is such that, by selecting the highest-yielding trees of any family, it will probably always be possible to get a clone with a higher yield than the average of the family from which it is derived.

The study of the nutrition of Hevea in pot cultures has been started (page 101). The use of growth-promoting substances for accelerating bark renewal has been tested, so far with negative results, but the use of palm-oil for this purpose appears to be effective (pages 105 and 125).

The ecological studies on associations of natural cover plants at the Experiment Station have continued and have yielded valuable information (pages 106 and 107). An interesting experiment on the planting of jungle areas without felling, the trees being

killed by frill-girdling and poisoning, has been started (pages 107 and 169).

The division of the time of officers of the Division, as between research and advisory work, in 1937 and 1938, was as follows:—

	Research percentage		Advisory percentage	
	1937	1938	1937	1938
Mr. Mann	34	37	66	63
Mr. Sharp	71	76	29	24
Mr. Guest	100	98	0	2
Dr. Baptist	95	96	5	4
Mr. Wright	78	69	22	31
Mr. Kaimal	91	97	1	3
Mr. Vaidyanathan	100	100	0	0

Pests and Diseases

In the Pathological Division the projected appointment of an Entomologist will relieve the pressure of advisory work and will enable more time to be devoted to research.

The root-disease investigations by Mr. Napper have been actively continued, and his field experiments on replanted areas are now beginning to yield instructive detail (pages 116—123). The effect of stump-poisoning, and of the reduction of starch-content of the roots points the way to possibly improved practical methods of control. Further experiments were laid down during the year.

The wintering and refoliation season was short in 1938, so that little time was afforded for Mr. Beeley's work on *Oidium Heveae*. Although the organism has still not been found in the terminal shoots, the lightning rapidity with which an outbreak can occur simultaneously over a large area, with no sign of the gradual spread of infection from a focal point, strongly suggests that the fungus hibernates in the green buds of the terminal shoots (page 129).

Reference has already been made to the engagement of an Entomologist, to work on the cockchafer grub pest. Mr. Napper's

observations indicate without doubt a real and general increase in the incidence of the pest throughout the country, though there is still no sign of its attaining epidemic proportions. Fumigation with carbon bisulphide is still the most effective means of control, but it is too expensive for use on any but relatively small areas. A programme of work on other possible methods of control was in preparation at the end of the year.

Further study of the "trail injection" method of termite control, by Mr. Napper, confirms the promise of this method (page 133).

Mr. Beeley's work on nodule bacteria for leguminous cover plants has been actively developed. Cultures of strains specific for all common species of covers are now available and have been widely distributed (page 138). A method for multiplication on the estate before use for seed inoculation has been worked out (page 139).

The relative times spent on research and advisory work by the officers of the Division in 1937 and 1938 were:—

	Research percentage		Advisory percentage	
	1937	1938	1937	1938
Mr. Beeley	53	58	47	42
Mr. Napper	42	36	58	64
Mr. John	95	93	5	7

Chemical and Technological Problems

The field of work of the Chemical Division, and its relation to that of the scientific staff of the London Advisory Committee for Rubber Research (L.A.C.), was fully discussed in my report last year (Annual Report 1937, pages 58 and 59). The reports for the Chemical Division and for the L.A.C. in this year's Annual Report should be read in conjunction.

Special attention is directed to the many aspects of variability of latex and rubber, in relation to problems of uniformity and the desire for standardisation on the part of manufacturers, which figure in the work of the Chemical Division in 1938 (pages 145, 148, 154—160). The discussions on this subject with manufacturers' representatives show that the present wide range in

manufacturers' requirements has been occasioned largely by the variability in the product, and that most manufacturers would have little difficulty in adapting their processes to deal with a standard product if it were available (page 207). It must again be be emphasized, however, that much of the variability is inherent in the trees and their environment, and so not readily controllable (see *e.g.* pages 145, 148, 154, 158).

Much work has been carried out on latex preservation (pages 146—149), and a means of effecting great reduction in the amount of ammonia, by its use in conjunction with another preservative, has been discovered.

Progress has been made in the study of latex concentration, particularly in connection with creaming (page 150).

Work on the preparation of modified rubbers has continued, and marked progress has been made in connection with the preparation of soft rubber on the estate by the addition of "peptising agents" before coagulation (page 153).

An interesting development from the study of the variation in softness of rubber from different clones (that from Clones P.B. 186 and Avros 152 is outstandingly soft, see page 158) is the study of individual seedling trees, and the establishment from them of new clones selected on account of the *quality* of the rubber (*e.g.* softness) rather than their yield (page 159).

The work on the drying of rubber has resulted in the development of a new type of Tunnel smoke-house which has advantages over existing types (page 160). It includes an improved type of furnace, which can also be used for other types of smoke-house (see next page).

	Research percentage		Advisory percentage	
	1937	1938	1937	1938
Dr. Rhodes	39	48	61	52
Dr. Roberts	100	94	0	6
Mr. Hastings	96	95	4	5
Mr. Piddlesden	51	52	49	48
Mr Wentworth	—	88	—	12
Mr. Sekar	67	62	33	38

The increased stocks of rubber which estates are now permitted to carry resulted in many enquiries regarding mould-prevention, and necessitated work on the influence of the use of para nitro-phenol on bubble formation during drying (page 161).

The percentages of the time of officers of the Division, devoted to research and advisory work, in 1937 and 1938, were as shown on the table on the previous page.

Experiment Station

The reports of Divisions refer to experimental work carried out at the Experiment Station, as part of their programmes.

The planted area increased by 85 acres to 1,141 acres, and the area in tapping increased by 198 acres to 725 acres.

The general manuring programme was extended, and continues to give marked evidence of benefit.

Considerable amounts of germinated seed and budwood were prepared and despatched for use in connection with Institute experiments on estates, and special arrangements had to be made to deal with this work.

The number of visitors to the Station showed a further increase, the recorded number being 725 (568 in 1937) including several parties from local branches of the Incorporated Society of Planters and District Planters' Associations and a number of visitors from outside Malaya (see page 190).

There was also an increase in the number of visitors for courses of instruction, consisting of five Europeans and 73 Conductors, whilst ten planters stayed at the Station for periods up to two weeks each.

Several new buildings were erected.

As a new departure, the Manager and Assistant Manager gave lectures to seven meetings of I.S.P. branches or D.P.As. They also made tours of Institute experiments on estates.

General

As in 1937, a small exhibit was staged at the Exhibition of the Malayan Agri-Horticultural Association in Kuala Lumpur in August, and the arrangement, staging and judging of the All-Malayan Small-holders' Rubber Competition were undertaken by officers of the Institute. The Institute was again open to the public during the period of the Exhibition, special exhibits and demonstrations being arranged. A total of 436 people visited the Institute during the show, including 25 Europeans, 29 Malays, 227 Chinese and 155 Indians.

The Institute assisted the artists who made the rubber diorama which was exhibited in the Malayan Pavilion at the Empire Exhibition at Glasgow; it also assisted in the arrangements for the making of the model estate factory shown there.

Exhibits were staged at 16 State or District Agricultural Shows, mostly by our Asiatic Rubber Instructors.

During the year 88 books were added to the Library, excluding pamphlets and scientific periodicals; the number of the latter regularly received is 350.

The visitors' book records 803 visitors in the year, as against 548 in 1937 and 398 for 1936. In addition there were about 280 visitors on the occasion of the Conference in July, 436 visitors during the M.A.H.A. Exhibition, and 725 visitors to the Experiment Station, a total of about 2,250.

A list of visitors from outside Malaya, totalling 96, is shown in an Appendix to this report. Among these, it was a particular privilege and pleasure to welcome Sir Frank Stockdale, K.C.M.G., C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, a member of the London Advisory Committee for Rubber Research (Ceylon and Malaya) and Vice-Chairman of the British Rubber Producers' Research Association; and to conduct him on visits to some of our experiments on estates, besides showing him the work in progress at the Institute and its Experiment Station. We were also glad to have visits from Mons. Ph. Langlois and Mr. J. G. (Now Sir John) Hay, of the International Rubber Regulation Committee.

Other visitors from overseas who, as members of the scientific staff of other research institutions or agricultural departments in the East and elsewhere, were specially welcome, were E. Bateson, (North Borneo); E. M. Crowther (Rothamsted Experimental Station, Harpenden, England); H. J. Channon (Liverpool University); J. Gandrup (Malang, Java); W. G. Higgins (North Borneo); G. M. Kraay and H. A. Leninger, (Proefstation West-Java, Buitenzorg); C. E. Rhines (H.A.P.M., Kisaran, Sumatra); W. H. Ten Broek (Goodyear Rubber Plantations, Sumatra).

I continued to serve on various outside committees (see Annual Report, 1937, p. 62).

Once more it is a pleasure to acknowledge the cordial relations and friendly co-operation which my staff and I have enjoyed with the Director and Adviser on Agriculture, S.S. & F.M.S. and many of his staff, and with the Controller of Rubber, Malaya, and his staff.

The opportunities for mutual consultation and help, with the Rubber Growers' Association, the United Planting Association,

the Incorporated Society of Planters, and the Malayan Estate Owners' Association have also been welcome.

I cannot speak too highly or gratefully of the loyal and friendly co-operation and help which I have had from all members of my staff, of all grades and races.

H. J. Page

Director

Kuala Lumpur

10th October, 1939

APPENDIX

Analysis of Correspondence by Divisions

Botanical Division

Subject	Letters Received	Letters Despatched
I. Budding		
General. Advice on choice of clones: Clone Records	437	486
Training of Conductors and Pupils from Estates, etc.	1	1
Field Experiments (Estate Trials)	2	1
Growth of Budded Trees	10	11
Purchases & Exchanges of Budwood	9	14
Packing and Treatment of Budwood	10	15
Import of Budwood	2	1
Special materials	1	1
	472	530
II. Tapping		
Estate Enquiries. General ...	37	43
Estate Experiments General	133	232
Estate Enquiries (Tapping of Budded Trees)	74	66
Estate Experiments (Tapping of Budded Trees)	254	172
Test Tapping of Seedlings ...	3	3
Utensils	7	9
	508	525
III. Selection		
Individual Mother-Trees-Selection on estates	3	2
Latex-Vessel and Bark Examinations	—	1
Isolation Gardens	11	14
Seed Germination	4	3
Seeds for Experimental Purposes	87	152
Requests for Seeds	1	1
Identification of Seed	5	4
Packing of Seeds	2	2
	113	179
IV. General Planting Enquiries		
Information on Planting Operations	44	49
Replanting	168	197
New Planting	81	96
Cover Plants	60	73
Thinning	5	5
Pollination	5	3
Vegetative Propagation	9	8
	372	431

Subject	Letters Received	Letters Despatched
V. Special Enquiries in connection with Rubber Assessment	40	36
VI. Planting of Experimental Areas on Estates under the Rubber Regulation Scheme	886	1,485
VII. Yields of Budded Rubber in Commercial Tapping	92	133
VIII. Apparatus	6	8
IX. Miscellaneous	69	154
GRAND TOTAL ...	2,558	3,481

Chemical Division

ANALYSIS OF CORRESPONDENCE, 1938

Subject	Letters Received	Letters Despatched
Latex	39	78
Latex Preservation	57	78
Latex Concentration	44	61
Latex—Instruments for determining D.R.C.	104	117
Anti-coagulants of Latex	5	5
Coagulation	23	25
Coagulating Tanks and Pans	11	13
Rubber Preparation—General Enquiries ...	21	17
Smoked Sheet	302	588
Air-dried Sheet	1	1
Crepe Rubber	11	15
Sole Crepe	3	7
Slap Rubber	1	1
Raw Rubber Powder	2	5
Water Samples	24	28
Machinery for Rubber Manufacture ...	26	51
Smoke-Houses	84	130
Vulcanisation of Rubber	33	49
Accelerators for Vulcanisation	4	6
New Uses of Rubber	1	1
Softened Rubber	9	16
Rubber Substitutes	1	1
Rubber Paving for Road Surfacing ...	2	3
Rubber Fillers	2	4
Rubber Seed Oil	—	1
Rubber Oil	1	1
Rubber Paints	3	3
Analysis of Rubber Goods	5	5
Baling of Rubber	2	2
Examination of Non-Hevea Rubber ...	4	5
Patents	10	13
Quebrachitol	2	1
Orders for Chemicals, etc.	6	8
Apparatus	21	28
Latex Compounding for Manufacture of Rubber Balloons	3	3
Miscellaneous	20	44
Correspondence with Manager Experiment Station	2	8
Meteorological Records	—	1
Materials for Lab Use	—	1
Books Review	—	1
TOTAL ...	889	1,425

Soils Division

ANALYSIS OF CORRESPONDENCE, 1938

Subject	Letters Received	Letters Despatched
Cultivation—		
General Enquiries	13	14
Forestry Methods	2	2
Experiments	38	53
Cover Crops and Natural Covers—		
General Enquiries	84	93
Manuring	21	23
Eradication by Weed Killers	15	20
Seeds	4	4
Manuring	487	586
Soil Conservation and Drainage	9	9
Catch Crops	5	6
Replanting	270	367
Fertilisers	85	84
Soil Samples	111	114
Experimental Planting under the Rubber		
Regulation Scheme	312	456
New Planting	26	27
Apparatus	5	4
Leaf analysis	15	15
Miscellaneous	75	101
TOTAL ...	1,577	1,978

Pathological Division

ANALYSIS OF CORRESPONDENCE, 1938

Subject	Letters Received	Letters Despatched
Root Disease	193	210
Stem and Branch Disease	73	77
Leaf Disease (Oidium Heveae)	117	121
Leaf Disease (Spider, Hel. etc.)	74	80
Fungicides and Insecticides	87	106
Spraying and Dustings	8	10
Brown Bast	6	10
Lightning Damage	13	17
Replanting	11	18
Cockchafer Grub	244	473
Insects on Rubber Trees	120	204
Insects on Cover Crops	96	62
Diseases of Cover Crops	15	19
Disease—general treatment	18	27
White ant treatment	39	39
Requests for Legume cultures	237	266
Miscellaneous	93	158
TOTAL ...	1,444	1,897

APPENDIX

Staff Movements in 1938

Officer	Appointment	Assumed duty	Went on home-leave	Returned to duty	Left the Service
T. N. Dickson	Assistant Manager, Experiment Station		9th April	13th October	
V. H. Wentworth	Chemist	6th May			
R. H. Meikle	Small-holders' Advisory Officer	15th May			
R. A. Hamilton	Soils Chemist				1st September
E. Rhodes	Head of the Chemical Division				12th September
C. C. T. Sharp	Botanist		28th October		
H. J. Page	Director		25th November		
K. C. Roberts	Chemist				18th December
W. H. Davey	Chemist, London Advisory Committee, toured Malaya, Ceylon and the Netherlands East Indies during the period 10th June to 4th October.				

APPENDIX

Visitors from Outside Malaya during 1938

R. W. Aitken, Bombay.
G. R. Armit, Soebang, Java.
F. D. Ascoli, Dunlop Malayan Estates Ltd., London.
S. W. R. D. Bandaranaike, Minister for Local Administration, Ceylon.
J. E. Barrs, Newton Chambers & Co., Ltd., Sheffield, England.
E. Bateson, Controller of Rubber, British North Borneo.
A. Berthier, Plantations d'Anloc, Indochina.
J. W. Bicknell, U.S. Rubber Co., Inc. New York.
M. Bocquet, Societe des Plantations Terres Rouges, Saigon, Indochina.
E. S. Burness, S.I.P.E.F., Antwerp, Belgium.
D. Carruthers, Kilmarnock, Scotland.
Prof. & Mrs. H. J. Channon, Higher Education Commission.
R. Chollet, Snoul, Indochina.
R. M. A. Claessens, Tapanoeli, Sumatra.
P. J. S. Cramer, Wassenaar, Holland.
E. M. Crowther, Rothamsted Experimental Station, Harpenden, Herts.
C. H. D. Curtoys, Shanghai.
W. S. Davey, London Advisory Committee for Rubber Research, London.
W. Deacon, Calcutta.
A. Denholm, Saigon, Indochina.
Stanley Dias, Colombo, Ceylon.
J. Doig, Mundakayam, Travancore.
R. Dolbey, Brunei.
J. M. Du Busson, London.
J. Dunkley, London.
G. K. Farquharson, Nougong, Assam.
M. D. Farrow, Soerabaya, Java.
J. Findlay, Thaton, Burma.
W. G. Freeman, Royal Empire Society, London.
Dr. Galliard, Hanoi, Indochina.
J. Gandrup, Malang, Java.
D. S. Gardner, London.
A. C. Gibson, Glasgow.
C. B. Graburn, London.
R. K. Hardwick, North Borneo.
J. G. Hay, London.
J. C. Henderson, London.
W. G. Higgins, Jesselton, B. N. Borneo.
T. W. Hodge, London.
John Hunter, Edinburgh.
T. Hunter, Shanghai.
W. D. Huntington, New York.
Jantzen, Garoet, Java.
P. Kamerman, Johannesberg, Africa.
M. D. Knapp, H.A.P.M., Sumatra.
I. B. Knight, Melbourne, Australia.
L. J. Kooiman, Soekaboemi, Java.
R. C. Kowe, Soebang, Java.
G. M. Kraay, Buitenzorg, Java.
Ph. Langlois, Paris.

M. J. N. Law, London.
G. Lecoindre, Paris.
H. A. Leninger, Proefstation West-Java, Buitenzorg, Java.
M. R. P. Lingard, Jesselton, B.N. Borneo.
J. Loontjens, Societe Financiere des Caoutchoucs, Medan.
Sir Wm. MacLean, Higher Education Commission.
R. Magerer, I.G. Farbenindustrie, Berlin.
W. Merves, Batavia, Java.
P. Michaux, Saigon, Indochina.
Callies Michelin, Clermont-Ferrand, France.
A. Mignen, Saigon, Indochina.
Miss. M. Mitchell, Coventry.
E. D. Money, Boustead Bros., London.
S. Mori, Tokyo, Japan.
J. R. Morris, Mergui, Burma.
J. L. D. Peiris, Colombo, Ceylon.
H. W. Peiris, Colombo, Ceylon.
Prachnap Bunnag, Bangkok.
N. Prasomdong, Bangkok.
B. M. Rao, Mysore.
K. G. Rao, Sumatra.
A. Reithinger, I.G. Farbenindustrie, Berlin.
C. G. Renshaw, London.
C. E. Rhines, Kisaran, Sumatra.
W. Richards, Rangoon.
A. J. Ritchie, London.
G. C. Robertson, Middletown, O., U.S.A.
W. Schmidt, I.G. Farbenindustrie, Frankfurt, Germany.
Ralph Sell, Hankow, China.
P. Stamberger, Vienna.
D. B. Stewart, Kuching, Sarawak.
Sir Frank Stockdale, Colonial Office, London.
W. T. H. Ten Broeck, Goodyear Rubber Plantations Co., Sumatra.
L. M. Thuan Komkris, South Siam Agricultural Experiment Station, Haadjai, Thailand.
J. van der Land, Medan, Sumatra.
W. W. Vogt, Goodyear Tire & Rubber Co., Akron, U.S.A.
von Rabenau, Indragiri, Sumatra.
von Schubert, Shanghai.
W. von Tirpitz, I.G. Farbenindustrie, Berlin.
R. Wauters, Societe Financiere des Caoutchoucs, Medan.
Mr. and Mrs. Weigall, Miri, Sarawak.
W. A. Welch, Shanghai.
H. M. Whitford, Rubber Manufacturers Association, America, New York.
J. Wilson, British Rubber Producers' Research Association, London.

ANNUAL REPORT

SOILS DIVISION

This report is presented in a form differing from that of previous years, the arrangement of items being now in conformity with that used in the programme of work, with the addition of sections on "Staff" and "Advisory Work."

Staff

The Division was unfortunate in suffering the loss of a Research Officer, Mr. R. A. Hamilton, Soils Chemist, who resigned his appointment and left Malaya on 30th August 1938 in order to take up a post in the Chemical and Animal Nutrition Division, Queen's University, Belfast, Northern Ireland. The vacancy thus created was filled by the appointment of Mr. G. Owen.

Three additional conductors were appointed early in the year to assist with recording work on field experiments. One temporary laboratory assistant resigned his post.

The future allocation of work amongst the graduate staff of the Division will be approximately on the following lines, although the distinctions made are not necessarily inflexible: Head of the Division will supervise generally the experimental and advisory work, particularly the experimental work on estates; Mr. G. Owen will be mainly in charge of laboratory and pot-culture work and certain field experiments; Dr. A. W. J. Dyck will be mainly in charge of advisory work and the supervision and inspection of certain field experiments; Mr. K. S. Pillay will supervise all routine laboratory work and some recording work on estate experiments.

I Soil Survey

During 1938 nearly 200 soil profiles were analysed, involving 12,854 determinations on 1,210 separate soil samples. A large proportion of this work was for the purpose of replacing information and records destroyed in the fire of 1936. The systematic classification and mapping of Malayan soils are being commenced from these analyses and from the field notes on the soils, but progress has been slow so far.

It is apparent that the inland soils, as classified and reported in the *Journal* of the Institute, Vol. 7, will need further sub-division into different types, although this will not necessarily mean that manuring and cultivation recommendations for rubber trees will differ appreciably for the different types. The system of classifying soils which is being used is based on the American system which defines

and classifies them on the basis of the properties of the soils themselves rather than on their relationship to geology, climate, vegetation, etc. With the very narrow range of climatic conditions occurring in Malaya this is a very suitable system to use. Soils are differentiated into Types, each Type being a combination of a Series and a Class. The Series characteristics depend on :—

1. Geological origin of the parent material
2. Mode of formation
3. Topographical position
4. Drainage
5. Profile characteristics

The soil class depends upon the texture of the surface soil.

The classifications which so far have been attempted are of a reconnaissance type and are on a very broad basis.

II. **Manuring of Hevea**

A. Mature Trees

The general position regarding manuring of mature rubber-trees has not altered appreciably during the past year, and the comments made in the report for 1937 still apply. The experiments in progress have produced results confirming previously expressed opinions. The area of estate rubber trees under steady manuring programmes is increasing appreciably and benefits, either in yield or in foliage, are generally being experienced. The series of experiments on coastal soils (clays and peats) which were commenced in 1936 in the Kuala Selangor district received a second application of fertilisers in 1938. The method of yield-recording will be simplified during 1939 and will be on the basis of cup-coagulation of a proportion of the trees for one tapping in the month. All the recording work will be under the supervision of an Institute conductor and it is anticipated that such a scheme will produce more reliable results than when latex is collected and brought in from the field in buckets by the tappers.

The records so far obtained have shown no benefits to the trees from manuring on the alluvial clay soils.

An experiment designed to compare different rates and frequencies of application of ammonium sulphate, in addition to uniform basal manuring with phosphates and potash, received its first manures in April 1938, and at the time of writing (February 1939) the wintering of the rubber trees (20 years of age) appears to have been appreciably affected. The whole area received the same quantities of phosphate and potash manures in April, but ammonium sulphate was applied at two different levels, 4 lb. and 6 lb. per tree, these

amounts being the total quantity which will be used over two years at three different frequencies of application, six-monthly, annually and every two years. In addition, three different times of application, April, September, and December, were included.

Observations during wintering show that April and September applications have had an effect on the rubber trees, resulting in a quicker refoliation, but that manures applied in December have not yet been utilised by the trees. Leaf analyses are also being made at six-monthly intervals, in addition to taking girth measurements and yield records.

One of the most interesting manuring experiments continues to be in Block 6, at the Experiment Station. The summarised monthly yields for 1938 show that the effects of different manures on yield are now quite well-defined and that treatment differences are fairly steady. During the first two years of tapping, apart from the distinctly higher yield from the 'NPK' treatments, there were considerable fluctuations in the relative yield levels of the plots receiving other manures, but throughout 1938 the treatments have held almost the same relative positions.

The 'N + P + K' manure is still producing the best yield, followed by the 'P + K' manure. Plots receiving cattle manure and those receiving sulphate of ammonia only are next in order, each at about the same level, whilst at the bottom have come the unmanured plots and those receiving 'N + P,' the latter being very definitely the poorest yielders.

Thus, the earlier conclusions from the experiment are further confirmed, namely, that potash is the main plant food deficiency in the Experiment Station soil, and it is not anticipated that any great changes between the yields of different treatments will occur for several years, in fact not until tapping approaches renewed bark. Once the first renewal of bark is tapped the early effects of manuring on yield are likely to be very much enhanced.

In one month (July) the yields from the 'P + K' plots exceeded those from the 'N + P + K' plots. The effect of introducing a new tapper for one month (August) was well demonstrated by the sudden, and otherwise inexplicable, large drop in yield in two plots.

The remaining sets of experiments on manuring of mature rubber trees have produced no unusual results or new developments yet, and it is sufficient to note that recording of growth and yields is continuing.

B. Immature Trees in New Clearings

Experiments on manuring of young immature rubber (*not* replanted), apart from the R.R.I. Experiment Station, are confined at present to areas being developed under the scheme of Experimental

Planting, and total 37 experiments on 32 different estates. Most are now budgrafted, and in addition to the general information on the effect of manures in different soils, comparisons will be made of the response of different clones to manuring. Budgrafting has in some instances introduced unevenness into the stand of trees, and a little time will be required before useful comparisons of clones can be made.

One of the outstanding results obtained from the measurements so far recorded is the very great influence of soil moisture on the growth of young rubber plants. This is most marked where planting has been done late in the season and dry weather has been quickly reached, and also on the more sandy soils. Unless the rubber plant has a well-established root system before the rainy weather ceases, it will receive very severe checks to growth throughout the dry season and into the next growing period. Retardation of growth for this reason has been shown to be often much greater than that which would be caused by omitting to apply fertilisers on certain jungle soils. Two important corollaries of this are to plant early and, particularly if dry weather occurs, to protect the soil and reduce soil moisture losses by mulching the surface around the young plants with cover weedings, etc.

Most jungle soils do not need immediate manuring, and so far the only responses detected have been to phosphatic fertilisers.

At the Experiment Station, general manuring has resulted in benefits to the rubber trees, and a small trial on very stunted trees has clearly demonstrated the value of potash fertilisers for stimulating new growth on the sandy soil of the Station.

The reaction of buddings of different clones to fertilisers is being studied generally in all the new-planting manuring experiments, and investigations are proceeding on several estates on the value of fertilisers for overcoming such peculiarities as abnormal defoliation which are manifested in some clones, *e.g.* S.R. 9, P.B. 186. The results as yet do not show that nutrition is an important aspect of these peculiarities, and it would appear that such abnormalities must be described as inherent characteristics of the clones concerned.

C. Replanted Areas

The success of replanting in general is more widely realised, although only tapping of the replanted trees and collection of yield records will provide the final proof of the success of the operations. The following points have emerged from a large number of experiments scattered all over the country.

(1) A large number of comparisons between 'Sterameal' and inorganic manures show fairly conclusively that growth is no better with one or the other of these types of fertilisers, although it has been claimed on one estate that better budding results were obtained

by using Sterameal. Using only ½ lb. Sterameal (on some estates 1 lb. has been used) as against 5 oz. of an inorganic mixture, the difference in cost per acre for the first application is approximately $4.50 extra.

(2) Bulky organic manures, such as cattle manure or "composts," have in several instances greatly improved growth during the first year of replanting, but it is not clear to what this improvement is due. It is very doubtful that growth is improved by any extra amount of plant food included in the organic manure, although possible factors are the beneficial effect from minor plant food elements and the stimulation of growth by organic substances which act as plant hormones. The probable value of these bulky organic fertilisers may lie in their purely physical action on the soil in improving its water-holding capacity and thus providing the young rubber plant with a more sustained supply of moisture.

Owing to the general increase of interest in compost-making by estates (a number of samples made on estates have been received for analysis) a series of trials for preparing compost at the Experiment Station was planned for commencement in January 1939.

In any case, the practical use of composts is limited, because of the comparatively small amounts of compost material or cattle manure which are available and also because the cost of application, except when made in the planting hole, will be high, involving extensive transportation and considerable digging.

(3) The use of dynamite in breaking up hard lateritic pans and masses in the soil is being investigated, and one experiment has given definite results already. The trees were budded in the field about a year after planting, and the growth of the six-months-old buddings demonstrates a very definite improvement owing to the use of dynamite, in combination with manure, over the use of manure alone. The action of the dynamite can be expected to produce benefits arising from the cracking of the hard lateritic layer and by the chemical action of the gaseous products of the explosion on the soil minerals.

Owing to the high cost of the dynamiting procedure ($25/- to $30/- per acre) its value as a means of improving heavily lateritic soils is necessarily dependent on the permanence of the growth improvement, and until this is established it is not possible to recommend the general use of explosives in such soils.

(4) Comparisons of different rates and frequencies of applying manures to young replanted trees have not yet indicated that applications at shorter intervals than six months or three months are more effective, which is at variance with some observations which have been reported.

(5) On coastal clay soils and on soils derived from Pahang Volcanic Series rocks manuring, so far, does not appear to be beneficial when replanting is done, and fertiliser applications at rates lower than normal ones or at longer intervals should be adequate. As conclusions become definite from the replanting experiments at present in progress, supplementary experiments will be started in order to elucidate other aspects of replanting procedure, particularly manuring, which emerge. Under this heading will come trials for determining the rate and frequency of manuring in the later years of immaturity and in the early years of maturity.

Maintenance of the early experimental plots until the trees attain maturity will considerably increase the importance and value of experiments, and it cannot be too strongly emphasized that although an experiment appears to have given final and definite results, the plot boundaries and the history of the area should be carefully preserved in order that further investigations on the tapped trees can be made.

D. Application of Manures

The mode and time of application of manures to rubber plants has not been the subject of much detailed investigation, and reference to experiments under this heading which were commenced in 1938 has been made under II A and II C (4).

(1) For mature rubber trees, manures are normally applied in strips between the tree rows, but the alternative procedure of placing the manure in a circular belt immediately around the tree must be considered in view of the fact that this procedure has been effectively used throughout North Borneo. Experiments are being started in 1939 to compare these two methods, and also the relative merits of broadcasting and forking-in of insoluble fertilisers, because obviously the economics of manuring can be appreciably affected if application costs can be lessened.

(2) For young rubber plants, it has not been clearly established on well-founded experimental facts, how soon manures will take effect on young seedlings or stumps after they are planted, and also exactly how manuring, immediately before or after budding in the field, affects the success of budding and the subsequent growth of the budgraft. These problems, and several other closely allied ones, are being examined in an experiment which has recently been commenced at the Institute's Experiment Station.

An investigation was started at the Experiment Station towards the end of December on the possible scorching effect of fertilisers when applied in baskets in which germinated seed are planted. Varying quantities of fertilisers up to 4 oz. per basket were used, and observations are being made on the effects of the manures as

shown by the occurrence of dead plants, leaf-scorch and retardation of growth.

III. **Cover Plants**

The work which is being done on cover plants really falls into two categories; there is that section which includes the study of their establishment, maintenance and control, and also that in which their effect on growth and yield of the rubber trees is examined.

A. In areas of mature rubber trees the establishment of leguminous covers has been the subject of experiments on estates and on the Experiment Station, and in addition a number of estates have been carrying out their own trials. Closely connected with these field experiments are the pot experiments carried out at the Institute and the work of the Pathological Division on Rhizobium bacteria. One estate, under the guidance of the Institute, has started its own series of pot trials for manuring covers. The experiments have been aimed chiefly at studying nutritional factors, methods of planting, and the effects of inoculation with Rhizobium, and, whilst the results are incomplete, it appears that in general it is essential, when attempting to establish legumes under old rubber trees carrying moderate foliage, to ensure :

(i) adequate phosphate supplies, preferably, at the start, in the form of basic slag; potash manuring is only advisable on the more sandy soils; minor elements may be of importance in some instances, but these can usually be provided in basic slag or smoke-house ash :

(ii) inoculation of the cover crop seed with Rhizobium bacteria (*i.e.* root nodule bacteria), which ensures a quicker establishment of the plants and also an adequate fixation of nitrogen :

(iii) freedom from competition from the rubber tree roots; this is achieved by digging over the planting strip and cutting the rubber roots :

(iv) adequate protection from pests (snails, slugs, rats); Metabran is a very effective poison bait to use.

In addition, the following factors can affect the success of the attempts to establish the legumes :— quantity of shade from the rubber trees; moisture conditions in the soil, as governed by soil type and texture and by the local climatic conditions; the type of cover which is used.

No one procedure or combination of operations has yet been evolved which ensures the successful establishment of a leguminous cover on average land under a normal stand of old rubber trees. The fact that on coastal clay soils *Centrosema pubescens* appears to flourish under even heavy shade suggests that soil moisture, which

is better retained in a clay soil, may be the limiting factor to successful growth of the legume. In Sumatra, leguminous covers are maintained under old rubber-trees for long periods of years merely by the periodical application of phosphatic manures, and usually no extra manuring is required to maintain the healthy and vigorous condition of the rubber trees. From this it has been argued that by establishing legume covers under old rubber trees in other situations, *e.g.* on estates in Malaya, the necessity for manuring the trees will disappear. This conclusion ignores the fact that on the Sumatran areas the soils are of comparatively recent volcanic origin, and that it is soil fertility and not the nitrogen-fixing properties of the legume covers which is responsible for the good condition of the rubber trees. Probably on such soils the type of cover has no material effect on the quality of the rubber trees.

It is felt necessary, therefore, to issue once again the warning given in this report last year, namely, that the heavy expenditure necessary to establish legumes under mature rubber trees should be approached very cautiously, and before any large-scale programme is tackled at least preliminary trials should be carried out.

B. 1. In newly-planted or replanted areas, in the absence of shade and root competition, covers establish comparatively easily, and most of the experimental work is concerned with methods of control and treatment of various types of covers. A number of areas under the Experimental Planting scheme contain specially designed experiments to include these points (*e.g.* digging-in, mulching, slashing).

2. The retarding effect of covers on the growth of young rubber plants is well-established, and a number of plots at the Experiment Station (Fields 11, 17, 19, 25) are devoted to measuring the retardation under different types of covers. The main retardation is caused by competition between the cover crop roots (which are established much more quickly) and the rubber plant roots, and experiments are in progress at the Experiment Station (Field 33 A) and on several estates to determine whether the competition is mainly for moisture or for plant foods and to study the value and economics of cutting the cover crop roots as a means of eliminating it. The indications so far are that, during the early stages of growth, competition for moisture is the chief factor involved.

IV. **Soil Management**

Under this heading, different methods of clearing land for new planting and replanting are being studied and they include comparisons of various procedures for mechanical treatment of soil which may be adopted for reducing soil erosion. Experiments have been started on eight estates under the scheme of Experimental Planting which

involve comparisons of clearing jungle by means of a heavy burn, a light (scorch) burn and no burn, also of planting on terraces and on platforms, and in the same experiments, the various cover crop effects, as outlined in Section III, will also be examined. The effects of all these factors on rubber plants of different clones are being estimated by growth measurements and, eventually, by yield records, and soil changes will be studied by the analysis of soil samples taken at different periods after commencing the treatments.

V. **Laboratory and Pot-culture Work**

The work carried out in the laboratory consisted of analyses of soils in connection with the soil survey (section I) and the field experiments (sections II, III and IV), and, for advisory purposes, numerous analyses of soils, estate-made composts, and local guanos were also made. A number of samples of rubber leaves were analysed for both experimental and advisory purposes. In all, analyses were carried out on 193 soil profiles and the total number of samples (soils, leaves, etc.,) dealt with during the year amounted to 2,119, involving 21,832 separate analytical determinations.

Certain specific problems, detailed below, were the subject of laboratory investigation :

(i) *Phosphate Status of Malayan Soils*—A preliminary study of certain selected soils was completed during the year. This involved the determination of phosphate availability by several methods, comparisons of phosphate fixation and silica sesquioxide analyses on clay fractions. The continuation of this work is planned for 1939, and is closely linked with the field experiments on phosphate manuring of young and old rubber trees. The results obtained to date are being prepared for publication in the *Journal*.

(ii) *Composition of Rubber Leaves*—Additional leaf analyses were carried out in 1938 and together with the earlier figures are undergoing statistical examination before a full discussion of the work is written up.

A more detailed study was commenced in October of the month-to-month variations in chemical composition of rubber leaves. Samples from a manuring experiment and from a clone trial at the Experiment Station are being used.

In several of the manuring experiments listed under section II, leaf samples from trees receiving different manuring treatments are being examined, and the analyses will be used to give indications of the effect of the manures.

(iii) *Soil Nitrogen and Organic Matter*—Pot-trials with *Centrosema pubescens* involving " inoculation " methods and manuring comparisons were carried on during the year at the Institute, and detailed analyses of the plants and of drainage water from the

pots were made. The results obtained are being examined in relation to soil nitrogen changes under covers, and arrangements are being made to procure soil samples from several of the cover crop experiments for the purpose of studying the effect of permanent covers on the soil.

Rubber leaf samples from the nitrogen manuring experiment were analysed to ascertain the effect of the first application of manures, made in April 1938.

VI. **Advisory Work**

Correspondence

A further increase occurred in the amount of correspondence dealt with in the Division, the total number of letters received being 1,577 and of those despatched 1,978. A detailed analysis, under subject headings, of this correspondence is included in the appendix to the report of the Director.

Manuring, replanting and cover crops have been the main topics of enquiry, and in addition 20 to 25 per cent of the total correspondence was in connection with experiments on estates.

Visits

The number of visits to estates was 267, an increase over those made in 1937; a large proportion of these were concerned with experiments in progress on estates.

Interviews

Visitors received at the Institute totalled 189, with whom all aspects of the work of the Division were discussed.

Lectures

The following lectures were given during 1938:—

Venue and Date	*Subject*	*Lecturer*
Kajang Branch Incorporated Society of Planters 22nd March	"Manures and Manuring"	R. A. Hamilton
Mentakab Branch, District Planters Association and Incorporated Society of Planters 22nd May	"Covers and their Effects on Rubber Trees"	C. G. Akhurst
Teluk Anson District Planters' Association 27th May	"Composts and Organic Manures"	A. W. J. Dyck

Kuala Lumpur Branch Incorporated Society of Planters and District Planters' Association 19th July	"Covers and their Effects on Rubber Trees"	C. G. Akhurst
South Kedah (Kulim) Branch, Incorporated Society of Planters 21st July	"Manures and Manuring"	R. A. Hamilton
Parit Buntar Club 11th August	"Organic Manures and Composts"	A. W. J. Dyck
Taiping Branch, Incorporated Society of Planters and District Planters' Association 12th August	"Organic Manures and Composts"	A. W. J. Dyck
Kuantan Branch, Incorporated Society of Planters 18th August	"Covers and their Effects on Rubber Trees"	C. G. Akhurst
Annual Conference Incorporated Society of Planters (Penang) 23rd—25th September	"New Planting"	C. G. Akhurst

All members of the Division attended the "Cover Crop" Conference held at the Institute on 29th July 1938, and papers and summaries were prepared and read by the Head of the Division and by Mr. R. A. Hamilton.

EXHIBITIONS, MEETINGS, ETC.

During the three days of the M.A.H.A. Exhibition, 30th July to 1st August, demonstrations and exhibits were held of the typical work of the Soils Division.

All members of the Division were present at the inaugural meeting of the Soil Science Society of Malaya, held at the Institute on 29th July 1938.

C. G. AKHURST

Head of Soils Division

Kuala Lumpur

13th April, 1939

ANNUAL REPORT

BOTANICAL DIVISION

During 1938 further progress has been made in the allocation of research and advisory work. The senior staff of the Division was brought up to full strength by the end of 1937 so that during the past year it has been possible for each member to devote a greater proportion of his time to the investigations that come within his province. The general distribution of advisory work and correspondence between all research officers has worked smoothly.

Staff and Organisation

No new appointments on the senior staff were made during the year. Re-organisation of the research programme was carried out in accordance with the plan outlined in the report for 1937 (p. 91-92.)

The principal divisions of the programme of work of the Division with the names of the members of the graduate staff concerned with each section are given below:—

1. Vegetative propagation ...	Mr. C. E. T. Mann, Dr. E. D. C. Baptist and Mr. K. N. Kaimal
2. Tapping Investigations ...	Mr. E. R. Guest and Mr. K. N. Kaimal
3. Selection and Breeding ...	Mr. C. C. T. Sharp and Mr. T. V. Vaidynathan
4. Physiological Investigations	Dr. E. D. C. Baptist
5. Ecological Work ...	Mr. K. N. Kaimal
6. Field Experiments on the R.R.I. Experiment Station	All members of the Staff of the Division
7. Field Experiments on Estates (Excluding tapping experiments) ...	Mr. N. Wright
8. Advisory Work ...	

The Head of Division and Mr. N. Wright undertake the major part of general advisory work but other officers of the Division

assist as occasion demands. All advisory letters and reports are circulated within the division so that each officer may keep in close touch with the trend of general work on estates in relation to his own and to other branches of the research programme.

Mr. C. C. T. Sharp proceeded on leave on 27th October, 1938. During his absence Mr. T. V. Vaidyanathan has continued work on hand pollination during the 1939 flowering season.

On the departure of the Director on leave on 23rd November, 1938, Mr. C. E. T. Mann was appointed Acting Director.

No other staff changes occurred during the year so that for the first time for many years the Staff of the division has been maintained at full strength for almost a complete year.

Brief reports of progress of the principal investigations follow below.

I. Vegetative Propagation

(1) Methods of Propagation and Planting

Budding

The use of cheaper materials for budding has been the subject of experiment. Tests with a method of binding using strips of coconut leaf and soft string in place of the usual waxed calico bandage gave satisfactory results.

An inexpensive type of rubber tape, made by the Ceylon Rubber Research Scheme, was also tested and gave very satisfactory results. The tape may be used several times and in districts where the rainfall is heavy, or when budding must be done in a wet season, this type of binding material gives better results than the waxed calico bandages which have been generally satisfactory under local conditions.

Propagation of Stocks

Investigations have been continued to study the effect of chemical growth promoting substances on the development of roots on cuttings of Hevea. The experiments reported last year showed that rooting of cuttings made from the basal portions of the primary stems of rubber seedlings, one to three years old, could be stimulated appreciably by treatment with dilute solutions of plant hormones. During the past season leafless cuttings from one and two-years old scions of a number of clones and cuttings made from one to three-years old branches from budded trees were treated with a wide range of growth promoting substances. Not a single case of rooting has been observed. Cuttings have developed a thin callus at the basal end and shoot and leaf growth

has been observed to continue presumably until reserve food is exhausted when the cuttings die. Attempts to induce rooting by first increasing carbohydrate reserves, by direct injection, and by ringing, followed by treatment with hormones have met with no success.

Further experiments with ringing of two-years-old buddings and the application of alpha-napthalene acetic acid in lanolin paste at the rings were tried. Callus formation at the rings was stimulated by treatment with the hormone substances at the lower concentrations used but the cuttings made from the ringed sections of the scions failed to produce roots.

The conditions for rooting were further studied using basal cuttings of young seedlings. It was found that the saturated atmosphere of a specially constructed propagator of the Trinidad type had no marked beneficial effect on the rate of rooting. Coarse-grained river sand forms a better rooting medium than a mixture of coir dust and fine sand used in earlier experiments.

Comparative tests of a wide range of substances indicated that alpha-napthalene acetic acid at dilutions of 0.03 to 0.06 gm. per litre (3 to 6 parts per 100,000) proved to be the most effective root stimulant for Hevea cuttings. A full account of this work is published in the *Journal.*(1)

Treatment of "Stump" plants to stimulate rate of Rooting

Treatment with growth promoting substances at suitable concentrations was found to stimulate the rate and amount of root formation on transplanted seedling stumps. The tests were repeated with budded stumps and confirmed that more rapid and prolific rooting may be induced by pre-treatment of stumps with hormone solutions. A circular on the practical application of these results was issued for use in advisory work to estates.(2)

(2) Stock-Scion Relationships in Buddings

Study of Seedling Root Systems

The study of root systems of six illegitimate families of clonal seedlings from clones Avros 49, 50, 152, 256, B.D. 5 and B.D. 10, were completed. Characteristic differences in form and distribution of the roots of the seedlings of different families, observed in the early excavations last season, have been confirmed by examinations on older plants. Certain seedling families have been chosen and planted for trial as stocks for budding.

(1) *J.R.R.I.M.* 9, page 17 *et seq.*, 1939.

(2) The stimulation of Root Formation in Hevea with Synthetic Growth Promoting Substances, Botanical Division Circular No. 13; August, 1938.

Clonal Seedlings as Stocks for Budding

(a) The experiment in Field 14E(2), described briefly in the last report, has been continued. Buddings of Clone P.B. 186 were made upon illegitimate clonal seedling stocks of the families Pilmoor A.44, B.50, B.58 and on illegitimate clonal seedlings obtained from budded areas containing a number of proved clones in mixed planting (M.A.P. Seedlings.)

This field was planted in December 1931 and a proportion of seedlings in each family were budded in December 1932 with Clone P.B. 186. All trees reaching tappable size have been tapped on a uniform system, ½ S, a.d., during the year and an extract of the results is given below:

TABLE I. *Growth and Yield of illegitimate Clonal Seedlings and of Buddings made on Seedling Stocks of the same families*

Origin of Seedlings	Seedlings			Buddings (P.B. 186)		
	No. of Trees	Mean Girth inches	Mean Yield gm. per tapping	No. of Trees	Mean Girth inches	Mean Yield gm. per tapping
1. Pilmoor A. 44	100	29.6	18.0	41	21.5	10.8
2. Pilmoor B. 50	105	30.2	17.4	55	22.1	11.2
3. Pilmoor B. 58	144	30.5	20.6	72	21.6	12.1
4. Mixed clonal seed (M.A.P.)	106	29.5	15.4	40	21.4	10.6

The differences in growth of the seedlings of all families in the above table are small but in yield the seedlings in 4 are inferior to those of the first three families. The growth and yield of the buddings on all stocks are remarkably even and there is very little indication from this experiment that the inherent yielding qualities of the stocks have had any appreciable influence on the yields of the buddings made upon them during the first tapping year.

(b) A younger experiment, commenced in 1935 on the Experiment Station, Fields 28 and 29, has provided further interesting data on the same subject. Illegitimate seedlings from

Clones Tjirandji 1, Prang Besar 23, Pilmoor B. 84 and Avros 256 were planted at the end of 1935 and budded one year later with Clones Tjirandji 1, Prang Besar 23, Pilmoor B. 84, Glenshiel 1 and Pilmoor D. 65. Girth measurements of the clonal seedling stocks and of the different scions grafted upon them are summarised below:

TABLE II. *Growth of Buddings on Clonal Seedling Stocks*

Origin of Seedlings	Mean Girth of Seedlings	Mean Girth of Buddings (all clones)	Mean Girth of Buddings of the different Clones—inches				
			Tj. 1	P.B. 23	Pil. B. 84	G. 1	Pil. D. 65
	inches	inches					
Tj. 1	11.2	6.2	6.1	5.9	6.1	6.6	5.8
P.B. 23	10.1	6.3	6.1	5.8	6.1	6.5	6.4
Pil. B. 84	10.1	6.1	6.1	5.7	6.1	6.0	6.1
Av. 256	10.4	5.5	5.6	5.7	5.6	5.9	5.6
Mean girth of different clones			6.0	5.8	6.0	6.3	6.0

The seedlings were three years old at the date of measurement and the buddings two years old reckoned from the date of budding in the field. These early measurements do not indicate that the growth of scions budded on related seedling stocks, *i.e.* illegitimate seedlings of the same clone, is influenced favourably or otherwise. Seedlings of clone Tjirandji 1 have made the most vigorous growth but they have not, when used as stocks, produced the most vigorous growth of the scions. It is interesting that the poorest growth in each clone is recorded on stocks of Avros 256 origin although the seedlings appear to be slightly more vigorous than those from Clones P.B. 23 and Pil. B. 84.

Experiments with "Twin" Plants

Twin Hevea plants, prepared by bisecting the young embryo soon after the emergence of the primary root and shoot from the seed, were first planted in March 1930 and further material has been planted in later years. The oldest trees have been tapped during 1938.

Twins were prepared from illegitimate seedlings of a number of different clones. The first series referred to below were planted as basket plants and the second series as stumps after one and half years of growth in nurseries.

Since it is impossible to give the two members of a twin exactly comparable conditions for growth and development in the field, perfect agreement in girth and yield cannot be expected.

However, tapping tests, on half-circumference alternate-daily for the first series and daily for a short period for the second series, have shown that twin plants have given almost identical yields.

TABLE III. *Comparison of Growth and Yield of Twin Seedlings*

Series	No. of Pairs	Girth in inches		Yield in gm. per Tapping	
		a—member	b—member	a—member	b—member
Field 4C ...	23	28.0	27.8	16.1	15.7
Field 25 (3) ...	65	19.2	18.9	11.3	10.7

In order to allow for differences which might be due to differences in growth of the two members of a twin on account of variations in soil and position, yields were re-calculated on the basis of yield per inch of tapping cut. When these figures are compared the very close agreement in performance of the two members of a twin is brought out more clearly. The values of the coefficients of correlation for yield of the a and b-members of twins were +0.86 for the first series and +0.74 for the second series.

In April 1932 buddings were made on the a-members of other twin seedlings planted in Field 4C. Budding was done at a height of 1 foot (30 cm.) from the ground and at the same time the b-members were cut back to the same level. Tapping was commenced in January 1937 at a height of 20 inches above the union on the a-members (budded) and 20 inches above the point of pruning on the b-members (not budded). The girth and yield records for the year 1938 are tabulated below.

The yields of the a-members of the pairs of twins which were tapped on the scion appear to bear very little relation to the yields of the b-members. The coefficient of correlation between the yields of a and b members is +0.25 indicating that there is no close relationship between the potential yield of the stocks and the yield of the scions grafted upon them. Further comment on these early results is postponed until larger numbers of similar pairs of trees have been tapped.

TABLE IV. *Girths and Yields of Buddings and "Twin" Stocks*

Clone budded on a—members	No. of Pairs	Girth at height of 30 ins. in inches		Yield in gm. per Tapping	
		a—member (budded)	b—member (not budded)	a—member (budded)	b—member (not budded)
P.B. 186 ...	9	24.0	29.0	16.7	16.1
Tj. 1 ...	9	26.6	25.4	25.1	12.2
B.D. 5 ...	3	20.8	28.8	14.3	12.2
Pil. D. 65 ...	7	25.2	26.0	18.4	12.7
All clones ...	28	24.8	27.0	19.6	13.6

Influence of Scion on Yield of Stock in High-budded Trees

(a) Tapping was commenced in January 1938 on high-budded trees in Field 10 on the R.R.I. Experiment Station. In this experiment, unselected seedlings were budded at different heights from the ground when they were nearly three years old. Control groups of trees were not budded but were pollarded at four feet from ground level at the time of budding.

Tapping was commenced six years after budding and tapping cuts were opened at an approximately uniform height of 24 inches from ground level on all trees.

The tapping cuts on the seedling trees were thus opened about two feet below the point of pollarding, on the budded trees the tapping cuts were opened either at the level of the union of scion and stock or from one to two feet above or below the union. The positions of the tapping cuts in relation to the point of budding, and girth and yield data for the first tapping year are summarised below:

During the first tapping year there has been no evidence that the scions have influenced the yields of the stocks. Although the yields of the trees tapped on the scion are on the average, slightly higher than those of the control seedlings, the yields from high-budded trees tapped below the union are lower than those of the control seedlings. It should be noted however, that the seedlings are the best developed trees; the check to growth of budding with a different scion has been greater than the check caused by pollarding. Further tapping records are required before it will be possible to draw conclusions from this experiment.

(b) Additional observations on the relative yields of stocks and scions of high-budded trees have been made on an estate.

TABLE V. *Tapping of "High" Buddings, Influence of Scion on Yield of Stock*

Group	Height of Budding above the Ground in inches	Initial Height of Tapping above Union in inches	Yield in gm. per tree per Tapping				
			Av. 50	Av. 152	S.R. 9	P.B. 186	Seedlings
A	2	+ 20	12.8	17.3	12.2	15.2	—
B	12	+ 10	10.5	13.3	11.8	14.2	—
C	24	0	9.8	14.3	10.8	11.3	—
D	36	— 10	9.2	11.4	9.6	9.3	—
E	48	—20	9.7	11.6	8.0	9.4	—
F	48 (1)	24 (2)	—	—	—	—	12.7
Mean girth at 24" in inches			26.6	27.9	26.5	27.4	31.4

(1) Pollarded at 48 inches from the ground
(2) Opened at 24 inches from the ground

Buddings of Clones B.D. 5 and Avros 256 were made on seedlings which were 3½ years old at the time of budding. The mean height of budding was approximately 18 inches above the ground.

In November 1936, five years after budding, two groups of 50 trees were selected for each clone; one group was tapped on scion commencing at 20 inches above the union, the second group was tapped on the stock, commencing just below the union. After one year the positions of the tapping cuts were reversed and the trees first tapped on the scion were tapped for a second year on the stock whilst the trees tapped on the stock during the first year were tapped on the scion during the second year. The results are given below, each record being from a group of 50 trees.

Position of Tapping Cuts	Period of Tapping	Yield in lb. per Tree per annum and Girth in inches at point of Tapping	
		B.D. 5	Avros 256
On Scion ...	Nov. '36—Oct. '37	6.3 (28.6)	3.6 (27.5)
	Nov. '37—Oct. '38	9.3 (29.8)	3.7 (29.5)
On Stock ...	Nov. '36—Oct. '37	7.2 (41.2)	6.9 (43.3)
	Nov. '37—Oct. '38	10.3 (45.0)	9.0 (46.1)

It was not possible in this area to compare trees which had not been budded, with the high buddings. The chief point of interest in the results is that the yields of the stocks do not differ greatly although there is a considerable difference in the yields of the scions grafted upon them. At first sight this would appear to indicate that the scion may have little influence on the yield of the stock and the results are in agreement with those of the first experiment described above.

It is emphasised, however, that these experiments must be continued for a longer period before reliable conclusions regarding influence of scion on stock can be drawn. It is quite possible that the influence of the scion crown on the quality of the bark below may only become evident after some years. The possible influence of the scion on the quality of the renewed bark developed below the union will also be investigated.

(3) Growth and Yield of Budded Trees

Comparative Trials of Clones at Sungei Buloh

Regular tapping of proved clones continued in Fields 5, 17A, 17D (South) and 21 and tapping commenced in Fields 10 and 22A (North) on 1st January 1938.

The principal data are summarised in Table VI, which gives the yields of the trees tapped alternate daily on a half circumference cut. Comparative yields on various tapping systems are given in the second section of this report.

The percentage of wind-breaks is calculated on the total number of trees of each clone in the plots regardless of tapping system and includes trees damaged both prior to and during 1938. The percentage of trees affected by brown bast disease represents the average number of trees out of tapping throughout the year and is calculated on the trees tapped on the $\frac{1}{2}$ a.d. system only.

Heavy supplying took place in Field 5 during 1930 and 1931 and the percentage of tappable trees is estimated on only those trees of the original planting which still survive. The amount of supplying necessary in Field 17, 21 and 22 was small, and the percentage of tappable trees is estimated on all trees and not on the original planting. In Field 10, although fairly heavy supplying took place, the percentage of tappable trees is also estimated on the total number.

A further thinning out to 125 trees per acre took place in Field 17D. Weak or stunted trees were removed and many poor seedling trees cut out. The latter were selected on yield and the present stand consists of 75 budgrafts and 50 seedlings per acre. The heavier thinning out of the seedling trees would tend to raise

TABLE VI. *Summary of Yield Records of Budded Trees on the*

(Yields of trees tapped alternate-daily

Field No.	Area in acres	Description of Field
5	40	Planted in November 1929 with budded stumps in monoclone plots of 121 points (11 rows x 11). Original stand: 108 trees per acre. Randomised block clone trial with 4 replications; plot centres (9 rows x 9) split for 3 tapping treatments in 1938. Age at commencement of tapping (Jan. 1936): 6 years.
10	10	Planted in February 1929. Budded at different heights (from collar to 48") from October 1931 to December 1932. Records from trees budded at normal height only. Age at commencement of tapping (Jan. 1938): 6¼ yrs.
17A	10	Planted October 1929. Budded December 1930. Interplanted April 1930 with unselected seedlings. Original stand 180 trees per acre in equal proportions of budgrafts and seedlings; stand reduced in 1937 to 125 trees per acre (86 b.d. and 39 seed.) Age at commencement of tapping (Jan. 1936): Budgrafts 5 years, seedlings 5¾ years.
17D South	10	Planted October 1929. Budded April 1931. Interplanted April 1930 with unselected seedlings. Original stand 180 trees per acre in equal proportions of budgrafts and seedlings; stand reduced in July 1938 to 125 trees per acre (75 bud. & 50 seed.) Age at commencement of tapping (Jan. 1937): Budgrafts 5¾ years, seedlings 6¾ years.
21	25	Planted in December 1929. Budded in October 1931 (polyclone budding in regular succession). Original stand 90 trees per acre. Randomised block tapping experiment with 6 replications, of 4 treatments set up in 1938. Age at commencement of tapping (January 1936): 4¾ years.
22A North		Planted in December 1930. Budded in December 1932 (polyclone budding in regular succession). Original stand 90 trees per acre. Age at commencement of tapping (January 1938): 5 years.

R.R.I. Experiment Station, Sungei Buloh

on half-spiral cut only)

Clone	Tappable Trees (percentage)			No. of Trees tapped a. d. (1938)	Yield in lb. per Tree per year (160 tappings)			Wind Damage (percentage) To end of 1938	Brown Bast (percentage) 1938
	1936	1937	1938		1936	1937	1938		
Avros 49	63	84	88	68	4.6	6.5	8.9	—	—
Avros 50	64	97	97	78	4.5	7.0	8.8	—	—
Avros 152	59	80	84	71	3.7	4.8	5.9	0.6	—
B. D. 5	18	75	93	71	4.1	5.3	6.6	0.5	—
Pil. A. 44	75	94	97	75	8.1	9.0	9.5	3.4	0.8
Pil. B. 84	86	98	98	82	5.8	8.5	9.2	—	0.4
P. B. 23	57	83	90	68	4.9	7.7	8.8	—	0.4
P. B. 186	74	88	99	79	4.9	8.1	9.5	0.6	—
Tj. 1	76	89	94	85	7.4	10.2	12.2	1.7	1.6
Avros 50			66	19			4.5	2.0	—
Avros 152			63	19			6.1	—	—
P.B. 186			70	21			5.4	2.0	—
S.R. 9			30	9			4.3	—	—
Avros 50	10	34	50	75	3.1	3.8	5.3	—	—
Avros 183	9	29	37	57	6.4	7.7	9.1	0.3	—
Avros 185	18	48	65	98	8.0	8.1	8.8	2.0	—
Glen. 1	26	44	57	86	6.4	7.6	9.2	—	1.0
Tj. 1	51	63	68	102	6.7	9.3	12.7	5.4	0.5
Tj. 16	16	39	52	78	6.4	7.4	8.3	—	—
Seedlings	79	100	100	384	3.2	4.9	5.4	1.0	0.8
Avros 50		23	41	58		3.7	3.8	—	—
Glen. 1		21	30	44		6.1	6.7	0.7	—
Rub. 393		24	37	54		2.9	3.4	—	—
Sab. 24		22	36	52		4.0	4.8	—	—
Tj. 1		45	50	74		7.2	7.1	2.0	—
Tj. 16		17	28	40		6.5	6.3	—	—
Seedlings		70	84	410		3.6	4.4	0.4	0.6
Avros 50	22	53	69	44	2.9	4.8	7.2	0.3	0.2
Avros 71	47	59	67	42	3.6	6.1	8.4	4.3	0.4
Avros 256	21	43	57	35	2.3	3.0	3.8	—	0.4
B. D. 10	40	55	72	35	3.5	6.5	7.8	3.7	0.4
Ct. 88	40	59	70	38	4.5	6.5	8.5	1.5	0.6
S.R. 9	9	25	42	23	2.9	4.8	5.8	0.3	—
Tj. 16	10	35	43	27	6.3	8.3	9.4	0.6	—
Avros 49			35	60			5.0	—	—
Avros 152			32	56			4.2	—	—
P. B. 186			33	56			4.3	—	—
Rub. 393			42	72			4.0	—	—
Tj. 1			47	76			7.5	4.0	0.4

their mean yields in comparison with the budded trees.

The yields of the clones tested calls for no particular comment. Clone Tjirandji 1 still remains the highest yielder on the poor soil of the Experiment Station; other promising clones which have done well there are Tjirandji 16, Pilmoor B. 84 and Glenshiel 1. The yields of AVROS 183, Prang Besar 186 and Pilmoor A. 44 are also satisfactory, but owing to defects in their secondary characters these last three are not generally recommended for commercial planting.

In general the rates of increase in yield declined in 1937-38. This may be attributed largely to the exceptional weather of last year, some clones, notably Pilmoor B. 84, being adversely affected by a dry season.

Influence of Density of Planting on Growth and Yield of Budded Trees

The summary of growth and yield records to the end of 1938 in the density of planting experiment in Field 14C and D at the Experiment Station is given in Table VII.

In order to eliminate boundary effects as completely as possible the effective size of the experimental plots has been reduced from 1.1 to 0.65 acres by excision of rather wide barrier belts from each plot. The actual boundaries of the plots from which records of growth and yield are taken have been permanently marked and records for the past two years have been corrected in accordance with the new boundaries. This accounts for the small apparent discrepancies between the girth records for the 6th and 7th years in the close-planted plots.

Growth and yield records are in accordance with expectations. It will be observed that highest yields have been obtained from the "C" plots, planted at 222 trees per acre, but that the yields of the denser plantings are increasing rapidly as new trees reach tappable size. The relative increase in yield of the plots planted at 435 trees per acre is most striking.

No thinning-out has been done or is intended in this experiment; losses are confined to trees removed on account of attacks by pests, disease or storm damage.

(4) Yield of Budded Rubber in Commercial Tapping

A circular was sent to some of the larger groups of Estates and to Agencies in April requesting returns from areas of budded rubber in commercial tapping. The response was varied, but by the end of the year returns had been received covering approximately 40,000 acres (monoclone, polyclone and mixed areas of buddings and seedlings).

TABLE VII. *Density of Planting Experiment (Field 14 C and D—R.R.I. Experiment Station)*

Planted, December 1930 with budded stumps of Clone Avros. 50

Plot Index	Planting Distance	No. of Trees per acre	Girth Measurements: Mean Girth in inches at the end of each Year of Life							Yield Data for 1937 and 1938: Per Cent Trees Tapped		Yield in lb. per Tree		Yield in lb. per Acre	
			2	3	4	5	6	7	8	1937	1938	1937	1938	1937	1938
A	30 ft. x 30 ft.	48	4.8	8.0	12.1	16.4	19.3	21.5	25.5	75	91	5.7	7.5	261.3	324.0
B	20 ft. x 20 ft.	108	5.1	8.3	12.1	16.3	18.7	19.1	21.0	64	74	5.7	5.8	345.8	458.1
F	20 ft. △	125	5.1	8.2	12.1	15.5	18.1	18.8	20.8	61	76	5.0	5.7	344.9	511.2
C	14 ft. x 14 ft.	222	4.9	7.8	11.5	14.8	17.1	17.3	18.8	51	65	4.2	4.0	421.2	563.9
D	12 ft. x 12 ft.	302	5.1	8.2	11.7	14.2	15.9	15.6	17.0	39	53	3.7	3.6	384.7	539.2
E	10 ft. x 10 ft.	435	5.2	8.1	11.1	13.2	14.7	14.1	15.4	20	34	3.9	3.5	262.6	463.6

Note. Girth Measurements. Up to the 6th year, *all* trees in each plot were measured ... ... Each Plot = 1.1 acres
After the 6th year, boundary belt trees are excluded from the records ... Each Plot =0.65 acres

Although the majority of the records referred either to short periods of tapping on the later developed first-class clones or to longer periods on clones which are now no longer recommended, the information obtained is most useful for reference. Some of the data was summarised by Mr. Wright in a paper presented to the Annual Conference of the Incorporated Society of Planters in September, in which the yields from commercial areas were compared with those obtained from tapping experiments.(1)

Further questionnaires will be sent out annually so that the trend of commercial yields can be followed in the future.

II. Tapping Investigations

Reference was made in the Annual Report for 1937 p. 97 to proposals for increasing the number and scope of tapping experiments in order to investigate further the problems which arose during the course of the experiment on Seventh Mile Estate and to undertake new work on the tapping of budded trees. Most of these proposals have been followed up during the year under review and by the end of the year the principal series of new experiments had been started on estates.

Mr. Sharp's investigation on Seventh Mile Estate was concluded in May 1938 and the summaries of the results for the fifth and last year of the experiment have already been published.(2) Meanwhile, Mr. Guest had selected suitable areas on different estates situated on different soil types to continue and extend the investigation of A.B.C. systems of tapping on mature seedling rubber.

Similar experiments have been started on young budded areas. The interactions between tapping, resting and manuring are also being studied in collaboration with the Soils Division. The small scale experiments in progress on the Experiment Station and on Pilmoor Estate have been continued by Mr. Kaimal.

In connexion with the large-scale experiments initiated on Estates, in all cases formal agreements have been made with the Companies concerned to ensure continuity of the work and to establish an equitable basis for compensation for loss of crop and the additional cost of the detailed work of recording and supervision which these experiments entail.

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(1) *Yields of Budded Trees in Commercial Tapping,* by N. Wright *The Planter* Vol. 19, p. 445, September, 1938.

(2) *Experiments on Economic Tapping Systems (1)* by C. C. T. Sharp *J.R.R.R.I.M.,* 8. p. 241-249—1938.

(1) Tapping Experiments on Seedling Trees

Comparison of Tapping Systems. Experiments to Compare a.d. with A.B.C. Tapping (Estates A to E.)

Sites were selected for a series of six experiments on low-, medium- and high-yielding rubber, 20-25 years old. After a preliminary period of two or three months on a uniform system (½ a.d.), comparative tapping commenced in all six experiments on November 1st. The types of rubber and level of yield ranged from two areas of poorly-grown trees of the "orchard type" on Estate E in South Johore (300–400 lb. class) to areas of well-grown high-yielding trees on Estates A and B in Selangor (500—600 lb. class). Two intermediate areas of medium rubber were selected on Estates C and D, also in Selangor (400—500 lb. class).

Each experiment consisted of three randomised blocks with four series of treatments, yields being recorded by half tasks:

(1) a.d., continuous alternate-daily tapping

(2) a.d., A.B.C. 4/2

(3) a.d., A.B.C. 8/4

(4) a.d., A.B.C. 12/6

that is to say, alternate-daily tapping for periods of 4, 8 and 12 months followed by periods of 2, 4 and 6 months rest in the respective series with normal tapping a.d. on half circumference as control.

As there were only two months of comparative tapping in 1938 the results will be held over until next year's report.

Comparison of Tapping Systems with and without Manuring

An experiment was set up on undulating loam soil at Estate F (Selangor) to compare the separate and combined effect of fertilizers and rest on comparatively young mature seedling trees. The tapping treatments were (a) continuous a.d. and (b) a.d., A.B.C. 6/3—six months alternate-daily tapping followed by three months rest. The fertilizer treatments were (a) no manure and (b) biennial applications of a complete inorganic mixture supplying about 65 lb. N, 45 lb. P_2O_5 and 20 lb. K_2O per acre. The layout is factorial with three replications, yields being recorded by half tasks.

The trees were 13 years old (planted on virgin soil) and had already been in tapping for three years when the experiment started on October 1st after six weeks preliminary records on a uniform tapping system (a.d.) The first three months results from this experiment will also be held over until next year's report.

Tapping on the Full Circumference of the Tree

The small-scale experiment on trees in Field 6 on the Experiment Station has been continued and the results for the whole period of the experiment, commenced in August 1935, are summarised below.

TABLE VIII. *Comparison of "Two-Cut" and "Full-Spiral" Tapping Systems*

Group No.	Position of Tapping Cuts	Frequency of Tapping	Yield as Percentage of Control (4 below)	
			Aug. 1935 to Dec. 1937	Jan.—Dec. 1938
1	Two left-to-right spiral cuts on ½-circumference. Upper cut opened at height of 40". Lower cut opened at height of 20" on opposite panel.	Alternate-daily 3 months tapping 3 months rest	87	110
2	As in 1 above.	Every 4th day "Double-four" No rest	104	129
3	Left-to-right spiral cut on full circumference. Opened at height of 30"	Every 4th day No rest	118	141
4	Single left-to-right spiral cut on ½-circumference Even-numbered trees opened at 40" Odd-numbered trees opened at 20". (Control).	Alternate-daily No rest	100	100

Note:—All tapping heights are measured from ground level to the lowest point of the tapping cut. Bark consumption is controlled so that the total bark consumption, measured in vertical units, is the same for all groups. The approximate heights of tapping in the 4 groups in January 1938 were as follows:—

Group 1—10 inches and 30 inches
Group 2—10 „ „ 30 „
Group 3—20 „
Group 4—20 „ „ 40 „

In December 1937 in the control group (4) the tapping cuts opened initially at 20 inches from the ground reached ground level and new cuts were opened in January 1938 at a height of 40 inches. The effect of this change has been to lower the yield of the control group in relation to the full spiral and two-cut groups. Taking this into consideration the relative yields of the experimental groups remains about the same as in previous years. Tapping on the full spiral system every 4th day continues to give very satisfactory results. There are no apparent ill effects on the trees after four years' continuous tapping on this system. Growth of the trees has been normal and bark renewal excellent.

Influence of Height of Tapping on Seedling Trees

An experiment was set up in Field 25(5), R.R.I. Experiment Station, to compare the yields of seedling trees at different heights of tapping. All tappable trees within a block of about eight acres were opened at 20 inches above the ground at the beginning of the year and tapped alternate daily on a half spiral cut for six months. In June the trees were arranged in the serial order of their total yields for the period January-May inclusive and grouped into four-tree blocks of similar yield. The total number of blocks obtained in this way was 100 (400 trees).

TABLE IX. *Comparison of Yields of Seedling Trees Tapped at Different Heights*

Series	Height of opening (July 1938)	YIELD in grams per tree per tapping and percentage comparison with series (1)				
		Preliminary period (Jan.—June) on cuts opened at 20 inches		First six months (July—Dec.) on new cuts		
		Mean Yield (78 taps)	Percentage comparison	Mean tapping height (ins)	Mean Yield (78 taps)	Percentage comparison
(1)	20 ins.	8.5	100	16½	10.7	100
(2)	30 ins.	8.6	101	26½	8.6	80
(3)	40 ins.	8.6	101	36½	7.4	69
(4)	50 ins.	8.6	101	46½	6.6	62

Field 25 (5)—Planted December 1931 with seed from high-yielding mother trees (P.B. clones, G. 1, S.R. 9, Sabrang 24, A.V.R.O.S. clones, etc.). Age at opening = 6 years.

Within each "block" the four trees were then allocated to four series on a random distribution and new panels opened on July 1st on the opposite side of each tree at the following heights from the ground respectively: Series (1) 20 inches, series (2) 30 inches, series (3) 40 inches and series (4) 50 inches. Individual tree records were continued as before. The mean yields for the remaining six months of the year, together with the yields for the preliminary period, are given in Table IX.

The results of this experiment to-date are in line with those of earlier experiments by Grantham and others. The rate of decline in yield decreases as the tapping cut gets further from the ground. Roughly, the yield decreases 1½ per cent for every inch that the tapping cut is raised. It is interesting to compare with this the results of the similar experiment on budded trees (*vide* Table XVI).

(2) Tapping Experiments on Budded Trees

Tapping of Mature Budded Trees

The tapping of the original series of buddings of the Pilmoor clones was continued. During 1938 all clones were tapped on renewed bark representing nine years' renewal. The data of girth, yield and d.r.c. of the latex of the two clones B. 84 and D. 65 are summarised below.

Table X. *Tapping of Mature Budded Trees—Pilmoor Clones*

Clone	B. 84					D. 65				
Year	1934	1935	1936	1937	1938	1934	1935	1936	1937	1938
Year of Age	10th	11th	12th	13th	14th	10th	11th	12th	13th	14th
Mean girth in inches at 40" from union ...	36.0	37.6	38.9	40.2	41.8	36.4	37.3	39.2	39.8	41.4
Mean yield in lb. per tree per year ...	18.5	19.2	21.5	17.7	19.4	26.0	23.2	23.0	17.6	21.2
Mean dry rubber content of latex per cent	38.0	38.2	37.8	39.6	37.2	32.8	31.0	36.4	34.3	29.0

Both clones show an increase in yield compared with 1937, but have not reached the level of 1936. Rainfall in 1938 was 75.13 inches—the lowest recorded since tapping started on this experi-

mental area, the previous lowest being 98.11 inches in 1936. Failure to reach the 1936 level of yield may have been partially or entirely due to the exceptionally dry weather.

In clone Pilmoor B. 84 two groups of trees have been tapped continuously since April 1939 on two systems; one group has been tapped daily in alternate months the other alternate-daily, both groups on half circumference. There are 18 trees in each group and when the test was started the average girths, and yields on the previous period of tapping on a uniform system, were practically equal.

Early tapping results gave a good indication that d.a.m. (daily tapping in alternate months) tapping might prove a better system than a.d. tapping for this clone and so in fact it did over the first seven years whilst tapping was on virgin bark and success was reckoned in pounds dry rubber without consideration of the possible effects of the two systems on the subsequent development and yields of the trees.

TABLE XI. *Yield and Growth of Budded Trees of Clone Pilmoor B. 84 tapped on the a.d. and d.a.m. systems on half-circumference. 1929 to 1938*

Year	Tapped a.d.		Tapped d.a.m.		Girth of d.a.m. Trees as per cent a.d. trees	Yield of d.a.m. Trees as per cent a.d. trees
	Girth inches at 40"	Yield pounds per year	Girth inches at 40"	Yield pounds per year		
1929	22.0	5.2	22.2	6.9	100.9	132.6
1930	24.8	7.1	24.7	8.1	99.5	114.0
1931	27.7	9.2	27.5	11.3	99.2	122.8
1932	30.5	12.3	29.8	14.3	97.7	116.2
1933	33.1	15.9	32.4	18.5	97.8	116.3
1934	36.0	18.5	34.4	20.0	95.5	108.1
1935	37.6	19.2	35.3	19.4	93.8	101.0
1936	38.9	21.7	36.7	21.2	94.3	97.6
1937	40.2	17.7	37.4	15.9	93.0	89.8
1938	41.8	19.4	38.3	18.3	91.6	94.3
Total for 10 years	—	146.2	—	153.9	—	105.1

But during the past five tapping years there has been a clear indication that the trees tapped a.d. are maintaining their level of production better than the trees tapped d.a.m. The better performance of the a.d. series becomes most noticeable from the beginning of 1937 when a change to a new panel just above eight years old renewed bark, was made.

There were too few trees (18 in each group) to give this test the degree of reliability required on such an important subject but the records summarised below provide a strong indication of the possible effect of d.a.m. tapping after the first few years on future growth and yield.

The figures above suggest that the better performance of the trees tapped d.a.m. during the first six years has been obtained at the expense of growth of the trees and to the detriment of future yields.

There is another indication of a more general nature that *both* the a.d. and d.a.m. systems without rest periods may have been too severe although the drop in yield in 1937 and 1938 may be accounted for in part by unfavourable weather conditions. However, too much stress is not placed on this observation for it is likely that the poor quality of the soil in this area is the most important factor in this connexion.

Response of Budded Trees to different Systems of Tapping

(A) Comparison of a.d., d.a.m and A.B.C. Tapping on Monoclone Plots of nine Clones

This experiment was set up on the Clone Trial in Field 5 on the Experiment Station early in 1938. This field was originally planted as a randomised block experiment with this object in view and contains nine clones in plots of 1.1 acres each. Each plot consists of a complex of 9 rows of 9 trees each, excluding a complete boundary row, and there are 4 plots of each clone.

The monoclone plot centres were each split into three subplots of three rows of trees, allocated at random to the following tapping treatments: (1) alternate-daily tapping, (2) daily tapping in alternate months and (3) alternate-daily tapping for six months followed by three months rest. Tapping continued on a half-circumference cut, as before, the average height of the cut for the year being about 20 inches above the union.

Comparative yields for the period February to December inclusive are tabulated on the opposite page.

The method of recording of yield in Series (1) is not the same as in Series (2) and (3) and it is feared that this may have introduced a constant error in the comparisons between a.d. and the other systems of tapping. A subsidiary experiment is being set

TABLE XII. *Comparison of different Tapping systems on nine Clones*

Series (1) $\frac{1}{2}S$, *a.d.*
„ *(2)* $\frac{1}{2}S$, *d.a.m.*
„ *(3)* $\frac{1}{2}S$, *a.d., A.B.C. 6/3*

Clone	Yield as per cent of Series (1)	
	Series (2)	Series (3)
AVROS 49 ...	114	77
„ 50 ...	108	69
„ 152 ...	133	84
B.D. 5 ...	88	75
Pil. A. 44 ...	114	80
Pil. B. 84 ...	100	83
P.B. 23 ...	115	91
P.B. 186 ...	92	70
Tjir. 1 ...	106	73
Mean all clones ...	108	88

Note: Relative intensities of tapping:—a.d. : d.a.m. : A.B.C. = 3 : 3 : 2.

up to compare the two methods of recording and to determine whether it will be necessary to correct the above figures. (see footnote)

Comparisons between d.a.m. and A.B.C. tapping and between the different responses of the clones to the same system of tapping should however be valid without correction. Considerable idiosyncrasies are exhibited by the various clones, the favourable response of clone Avros 152 to d.a.m. tapping being outstanding, while clones B.D. 5 and P.B. 186 show an appreciable loss in yield on this system.

Before this experiment was started Field 5 was tapped on a uniform system, alternate-daily tapping on half-circumference of the trees and latex was collected separately from each of the 36 plots. This latex was used as a source of supply of "clonal latex" for work in the Chemical Division. When this tapping experiment was started it became necessary to change the method of recording to the cup coagulation method for the A.B.C. and d.a.m. sub-plots but in order not to interfere with the Chemical Division experiments the a.d. sub-plots were kept on the original method of recording. It was not anticipated that the difference in methods of recording would introduce any serious error but since the magnitude of the error is in doubt the figures in Table XII may need correction later. In the experiment in Field 21, where a uniform method of recording is used, the results obtained with Clone Avros 50 indicate that the error may not be large.

B. Comparison of a.d., d.a.m., and S. 4d. (Full spiral, fourth daily) Systems of Tapping on seven Clones

A second tapping experiment on young budgrafted trees was set up in Field 21, the layout being six randomised blocks with four tapping treatments. The four series were as follows: (1) alternate-daily tapping on half-circumference, (2) and (3) daily tapping in alternate months, also on half-circumference, and (4) tapping every fourth day on a full circumference. In series (1), (2) and (3) tapping continued on the same panels as before. In series (4) the existing cuts were lengthened upwards from a half to a full spiral, the old marking channel being plugged with wax to prevent overflow of latex down the centre of the new panel. The average height of cut for the year was about 30 inches above the union (measured from the bottom of the cut on all systems). Owing to the different rates of bark consumption the average height on the 4d. system may be reckoned as an inch or two above this and on the a.d. or d.a.m. systems as an inch or two below.

Comparative yields for the period February to December 1938 inclusive are tabulated below.

TABLE XIII. *Comparison of different Tapping Systems on seven Clones*

Series (1) a.d.
Series (2) and (3) d.a.m. (2) "odd" months (3) "even" months.
Series (4) S. 4d. Full-spiral every 4th day.

Clone	Yield as per cent of Series (1)	
	Series (2) and (3)	Series (4)
Avros 50 ...	113	140
Avros 71 ...	101	120
Avros 256 ...	130	67
B.D. 10 ...	111	131
Ct. 88 ...	116	200
S.R. 9 ...	100	99
Tj. 16 ...	100	101
Mean (all clones) ...	110	123

Note: Relative intensities of tapping:—a.d. : d.a.m. : S, 4d. = 1 : 1 : 1

As in the previous experiment, the various clones exhibit marked individual responses to different systems of tapping. Clone

Avros 256 (which does very badly on the poor sandy soil at the Experiment Station) shows a considerable drop in yield on S, 4d. tapping; many of the trees of this clone went dry for periods of several months. Clone Ct. 88, on the other hand, has given double its normal yield on this system, and the increases recorded for some of the other clones are also large.

The mean increase for all clones on d.a.m. tapping in Field 21 is similar to the value found in Field 5. The only clone common to both experiments is Avros 50 and the d.a.m. results on this clone show reasonably close agreement (113 and 108 respectively) in the two experiments. Since there is a uniform method of recording by cup coagulation in Field 21, this indicates that the error introduced by the different recording methods in Field 5 may not be large.

C. Comparison of Tapping Systems, including "Full Spiral," on Buddings of some Prang Besar Clones

For this experiment on young budgrafts a suitable site was found at Estate H (Selangor), where a clone trial with five clones replicated in six randomised blocks on hilly land had been laid out at the time of budding in 1931. The clones represented are P.B. 23, P.B. 86, P.B. 183, P.B. 186 and S.R. 9. In addition to these clones, duplicate tasks of Avros 256, B.D. 5 and P.B. 24 are scattered through the area, but do not form part of the main experiment. To superimpose the tapping experiment on the clone trial a factorial layout was adopted, the following five tapping series being chosen: (1) ½S, a.d., (2) 1/3S, a.d., (3) ½S, 3d., (4) S, 4d. and (5) and (6), ½S, d.a.m. (one plot of each clone always in tapping and one resting).

In April at about 6½ years old the percentage of tappable trees over the whole area was 66 per cent, the tappable percentage for each clone being as follows: P.B. 23—70 per cent, P.B. 86—67 per cent, P.B. 183—68 per cent, P.B. 186—73 per cent and S.R. 9—54 per cent. The young trees were opened at 40 inches above the union and brought into tapping on a uniform tapping system (½ a.d.) at the end of November. Preliminary records of yield were kept throughout December in readiness for the experiment to start on January 1st, 1939.

D. Comparison of a.d. with A.B.C. and other Systems of Tapping in large-scale Experiments on Monoclone Areas

The tapping experiments set up in collaboration with estates on monoclone plantings of a number of proved clones have been continued. Several new experiments have also been planned.

Large-Scale Tapping Experiments

TABLE XIV. *Yield in pounds per acre per annum and Percentage*

(Numbers in brackets denote the number

Experiment No. :—		No. 1			No. 2		
Locality :—		Estate J (N.S.)			Estate K (Johore)		
Clone :—		P.B. 25			AVROS 49		
Age first tapped :—		5 years			5½ years		
Tapping System :—		a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.
1st Year	Yield, lb. per acre ...	578			517		
	Tapping days ...	(171)			(114)		
2nd Year	Yield, lb. per acre ...	760	540	545	555	403	386
	Tapping days ...	(175)	(117)	(117)	(141)	(96)	(97)
	Percentage of a.d. ...	*100*	*71*	*72*	*100*	*73*	*70*
3rd Year	Yield, lb. per acre ...	940	704	728	792	600	576
	Tapping days ...	(179)	(119)	(119)	(146)	(98)	(97)
	Percentage of a.d. ...	*100*	*75*	*77*	*100*	*76*	*73*
4th Year	Yield, lb. per acre ...	918	760	702	917	767	652
	Tapping days ...	(169)	(112)	(112)	(150)	(100)	(99)
	Percentage of a.d. ...	*100*	*84*	*76*	*100*	*84*	*71*
5th Year	Yield, lb. per acre ...	1397	741	751			
	Tapping days ...	(173)	(116)	(116)			
	Percentage of a.d. ...	*100*	*53*	*54*			

TABLE XV. *Mean Yield in pounds per acre per annum and of comparative test*

Period of Comparative test :—		4 years			3 years		
Clone :—		P.B. 25			AVROS 49		
Tapping System :—		a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.
Yield		1004	686	682	755	590	538
Tapping days		(174)	(116)	(116)	(146)	(98)	(98)
Percentage of a.d. ...		*100*	*68*	*68*	*100*	*78*	*71*

on Monoclone Areas

Comparison of other Systems with a.d. System

of tappings on each system)

No. 3			No. 4			No. 5		
Estate K (Johore)			Estate K (Johore)			Estate J (N.S.)		
AVROS 50			AVROS 152			S. R. 9		
5½ years			5½ years			6 years		
a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.
464 (149)			392 (144)			484 (167)		
522 (143) *100*	321 (96) *61*	313 (97) *60*	441 (138) *100*	262 (92) *59*	269 (93) *61*	558 (180)		
786 (150) *100*	551 (99) *70*	510 (99) *65*	635 (147) *100*	445 (102) *70*	428 (101) *67*	640 (169) *100*	422 (112) *66*	462 (112) *72*
887 (154) *100*	665 (103) *75*	605 (102) *68*	791 (155) *100*	590 (103) *75*	562 (103) *71*	689 (174) *100*	490 (116) *71*	502 (116) *73*

Percentage Comparison with a.d. system for the whole period (preliminary period excluded).

3 years			3 years			3 years		
AVROS 50			AVROS 152			S. R. 9		
a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.	a.d.	A.B.C.	3d.
732	512	476	622	432	420	665	456	482
(149)	(99)	(99)	(147)	(99)	(99)	(172)	(114)	(114)
100	*70*	*68*	*100*	*69*	*68*	*100*	*69*	*72*

First Series (started 1933-34)

Each of these five experiments occupies 18 tasks of about 300 trees, or approximately 60 acres. The three treatments compared are the normal system of alternate-daily tapping (½ a.d.), the A.B.C. system of alternate-daily tapping for six months followed by three months rest (½ a.d., A.B.C. 6/3) and the third-daily system (⅓, 3d.). Tapping was commenced at a height of 40 inches from the union with a left-to-right spiral cut. The tapping cuts on all three systems are over half-circumference. During the past year the second panel was opened, also at 40 inches, in the a.d. series of all five experiments and in the 3d. series of Experiment No. 1. In the other series the cuts are still on the first panel, now not far above the union.

The oldest experiment on clone Prang Besar 25, has been in progress for over five years. The other experiments, on clones Avros 49, Avros 50, Avros 152 and Sungei Reko 9, have been in progress for just over four years. The principal results are summarised in Table XIV on pages 82 and 83.

The actual yields of the different clones cannot validly be compared as the experiments are set up in different localities under different conditions. The yield obtained from each clone on a.d. tapping is satisfactory. All these experiments show evidence that yield is depressed as the tapping cuts reach the base of the panel. This is no doubt partly due to awkwardness of tapping at low levels and partly to the approach to the union. The effect is particularly marked in Experiment No. 1 on clone P.B. 25 where the cuts in the a.d. series reached the vicinity of the union during the fourth year and in the other two series during the fifth.

As in previous years, the chief point of interest in the figures is that reduction in the number of tapping days is reflected in an almost proportional loss in crop. This can best be seen in Table XV (pages 82 and 83), which gives the mean yields over the whole period of comparative test for each clone; the combined results for all clones are given below:—

Tapping System	Comparative Yield	Mean Annual Intensity of Tapping*	Comparative Intensity
½ a.d. ...	100	78.8	100
½ a.d., A.B.C. 6/3	71	52.6	67
⅓, 3d. ...	69	52.6	67

Note: *Intensity of tapping = length of cut × average number of tappings per annum, in full circumference units.

The comparative yields are in close ratio to the comparative intensities of the three systems. In the experiment on P.B. 25, a clone believed to be rather susceptible to brown bast disease, a count of dry trees half way through the fifth year gave the following results: (1) a.d. series 7.8 per cent, (2) A.B.C. series 4.3 per cent and (3) 3d. series 2.2 per cent. Should the incidence of brown bast increase in the a.d. series the advantages of the lighter systems of tapping may become more apparent. Up to the end of 1938 neither girth nor bark measurements have shown any significant difference between the effects of the three tapping systems on the growth and vigour of the trees.

The results still show that for young buddings of these five clones the normal system of alternate-daily tapping on a half-circumference may not be too severe a system, but the incidence of brown bast in clone P.B. 25 will have to be watched. Neither reduction in the frequency of incision nor alternation of periods of rest have produced any measureable benefit on these young trees to offset the loss in crop.

In a subsidiary experiment on Estate J the daily alternate-monthly system (½ d.a.m.) was compared with the normal ½ a.d. system on clone S.R. 9, some tasks adjacent to Experiment No. 5 being used for this purpose. The comparative yields obtained on the two systems during the first year of the experiment (in the third year of tapping) were in the following ratio:

a.d. series : d.a.m. series = 100 : 86.

A graph of the mean daily yield per serial tapping day after rest showed that the peak of the d.a.m. curve did not exceed the level of yield obtained on continuous a.d. tapping. These results show that daily alternate-monthly tapping is not a suitable system for clone S.R. 9.

Influence of Height of Tapping on Budded Trees

(a) The results of the small-scale experiment set up on the boundary row trees in Field 5 to compare the yields of trees opened at heights of 20 inches and 40 inches from the union were presented in full in the Annual Report for 1937 p. 103. It was shown that the trees opened at 20 inches from the union gave slightly higher yields than those opened at 40 inches from the union during the first tapping year but that the differences during the next two years were small.

Tapping year	1st	2nd	3rd
Yields of buddings opened at 20 inches:—	100	100	100
Yields of buddings opened at 40 inches:—	91	97	99

In January 1938 the trees originally opened for tapping at 20 inches from the union were re-opened on the opposite panel at 40 inches from the union. Thus, the low-tapped trees of the first

cycle of three years continuous tapping became the high-tapped trees for a second cycle and the comparison is being continued. During 1938 the average yield of the buddings tapped at 40 inches was 92 per cent of the yield of buddings tapped at 20 inches. The relationship found in the first year of the experiment is thus closely confirmed.

(b) A further experiment was set up in Field 22A on the Experiment Station to compare the yields of budded trees of five clones (Avros 49, Avros 152, P.B. 186, Rubana 393 and Tj. 1) at different heights of cut. All tappable trees in this polyclone area were opened at 40 inches above the union at the beginning of the year and tapped alternate daily on a half spiral cut for six months at this uniform height. In June the trees were arranged in the serial order of their total yields for the period January to May inclusive and grouped into four-tree blocks of similar yield within each clone. The total number of blocks obtained in this way was 80 (320 trees), each of the five clones being represented by between 14 and 19 blocks.

Within each block the four trees were then allocated to four series on a random distribution and new panels opened on July 1st on the opposite side of each tree at the following heights above the union respectively: Series (1) 20 inches, series (2) 30 inches, series (3) 40 inches and series (4) 50 inches.

Individual tree records were continued as before. The mean yields for the remaining six months of the year, together with the yields for the preliminary period, are given in Table XVI.

TABLE XVI. *Comparison of Yields of Budded Trees (Means of all Clones) tapped at Different Heights*

Series	Height of opening (July 1938)	YIELD in grams per tree per tapping and percentage comparison with series (1)				
		Preliminary period (Jany.—June) on cuts opened at 40 inches		First six months (July—Dec.) on new cuts		
		Mean Yield (82 taps)	Percentage comparison	Mean tapping height (ins.)	Mean Yield (77 taps)	Percentage comparison
(1)	20 ins.	10.2	100	16.5	20.4	100
(2)	30 ins.	10.2	100	26.5	20.1	99
(3)	40 ins.	10.4	102	36.5	18.5	91
(4)	50 ins.	10.4	102	46.5	17.5	86

Field 22A—Planted Dec. 1930. budded Dec. 1932.
Age at opening = 5 years.

To date this experiment shows a difference in yield of less than 10 per cent between the trees opened at 40 inches in comparison with those opened at 20 inches. It is interesting to note that this relationship is practically identical with the one found in the preliminary experiment in Field 5 (A above) during the first year.

In both experiments detailed examination of the results reveals considerable differences between clones in their responses to tapping height but these results will not be presented until this experiment (B) has been running for a longer period.

It is of interest to compare the difference in response of buddings and seedlings to differences in tapping height during the first tapping year in the preliminary, small-scale experiments and in the later large-scale experiments set up in 1937-1938.

(Reference is made to the data in Tables IX and XVI in this report and to Table VIII p. 103 of the 1937 report)

Experiment			Comparative yields of trees opened at	
			20 inches	40 inches
Field 5	Buddings	1st year	100	91
Field 6	Seedlings	1st year	100	54
Field 5	Buddings	4th year	100	92
Field 6	Seedlings	4th year	100	61
Field 22A	Buddings	1st year	100	91
Field 25 (5)	Seedlings	1st year	100	69
Mean, Buddings			100	91
Mean, Seedlings			100	61

The data illustrate clearly the marked difference between buddings and seedlings in their response to height of tapping, the differences in yield at the tapping levels considered being approximately 10 per cent for buddings and nearly 40 per cent for seedlings.

"Double-cut" Tapping on Budded Trees

The small-scale experiments on tapping budded trees with two cuts on half circumference on opposite sides of the tree have

been continued. The original series of experiments on Clone B.95 on Pilmoor Estate and on the nine clones in Field 5 on the Experiment Station were reported in full in the last report p. 105 and call for little further comment here.

In the experiment in Field 5, the change from periodic tapping, a.d. tapping on 2 half-circumference cuts for periods of 3 months with 3 months rest, to tapping on 2 cuts every 4th day without rest continues to give satisfactory results. The mean yields of trees tapped on the double-cut system were slightly higher than those of the controls tapped on half circumference alternate daily. The double-cut system is similar in principle to the full spiral system since tapping on the full circumference of the tree is done in one operation.

Comparison of Tapping Systems with and without Manuring on Budded Trees

(A) Comparison of a.d., d.a.m. and A.B.C. Tapping with three levels of Manuring on a polyclone planting of Prang Besar Clones

A field of young budgrafts on undulating loam soil in their fourth year of tapping at Estate G (Selangor) was chosen as the site for this experiment. The exact composition of this polyclone planting was uncertain, but the following clones had originally been planted in the area in regular succession at a density of 193 trees to the acre: P.B. 23, P.B. 25, P.B. 31, P.B. 86, P.B. 123, P.B. 126 and S.R. 9. By the middle of 1938, when the experiment was laid out, the stand had been thinned to a density of 150 trees to the acre which was then reduced to 120 by removal of stunted and diseased trees. It is hoped to determine the exact composition of the plots by an accurate census at a later date.

The experiment was arranged on a factorial layout with three tapping treatments and three levels of manuring replicated in two blocks. The three tapping series were (1) a.d., (2) a.d., A.B.C.6/3 and (3) d.a.m., all on half spiral cuts. The height of cut was irregular owing to trees having been opened for tapping at a standard height on attaining maturity, but full details were recorded so that the mean height of cut in each plot can be determined.

The three fertilizer series were (0) no manure, (1) and (2) biennial applications of a complete inorganic mixture supplying respectively unit and double dressings of 27½ lb. N: 30 lb. P_2O_5: 18½ lb. K_2O per acre.

The experiment started on July 1st, following a month's preliminary records on a uniform system of tapping (½S, a.d.). After correcting for the original level of yield in each series, the relative total crop harvested on each of the three tapping systems during the first six months is given in Table XVII, below:

TABLE XVII. *Comparison of Yields of Budded Trees (Polyclone Planting of P.B. clones) tapped on three Systems, with relative intensities of Tapping*

Tapping System	(1) a.d.	(2) A.B.C.	(3) d.a.m.
Relative Yield (July—December, 1938) ...	100	73	107
Relative Tapping Intensity ...	100	67	100

(B) Comparison of a.d. and d.a.m. Tapping with four levels of Manuring on a Monoclone Planting of B.D. 5

This experiment was set up on a monoclone area of B.D. 5 on inland alluvial clay loam at Estate I (Perak). Towards the end of July the young trees were opened at 25 inches above the union on a half-spiral cut and brought into tapping at the age of 7½ years. Preliminary records of yield were kept for one month on a uniform system of tapping (½S, a.d.) and the experiment commenced on September 1st.

The plots were arranged on a factorial layout with four replications of the following treatments:—

Tapping series: (1) alternate-daily tapping, (2) daily tapping in alternate months.

Fertiliser series: (0) no manure, (1), (2) and (3) two annual applications to be succeeded by biennial applications of a complete inorganic fertiliser supplying approximately 21½ lb. N: 20 lb. P_2O_5: 6½ lb. K_2O per acre at (1) unit, (2) double and (3) treble rates of dressing respectively.

Comparative yields (total crop harvested) on the two tapping systems during the first four months are given below.

TABLE XVIII. *Comparison of Yields of Budded Trees of Clone B.D. 5 on two Systems of Tapping*

Tapping System	(1) a.d.	(2) d.a.m.
Relative Yield (September—December 1938) ...	100	94
Relative Tapping Intensity ...	100	108

Plots of the d.a.m. series were given a "flying start" at the beginning of each tapping period in accordance with the common practice in Sumatra. The cuts were reopened after rest on the last two afternoons of the resting month, so that the tapping intensity was 8 per cent greater on the d.a.m. system than on normal a.d. system. In spite of the greater intensity, the yield on d.a.m. was well below a.d. over this short period of four months, indicating that clone B.D.5 probably does not respond favourably to daily, periodic tapping. This suggestion is supported by the results obtained in the experiment in Field 5 on the Experiment Station where the yield of Clone B.D. 5 on the d.a.m. system appears to be about 12 per cent less than the yield on the a.d. system (Table XII).

III. **Selection and Breeding**

New Clones from Estate Mother-Trees (Field 15. S)

Tapping of the "Estate" clones in Field 15 on the Experiment Station was continued throughout the year and a small number of new clones budded in 1933 were brought into tapping. The most promising clones with yield records for the years 1937 and 1938 are mentioned below. Throughout this Field, Clone Avros 50 was planted for comparison with the new unproved clones and as the quality of the soil shows wide variations throughout the field yields of each clone should be considered in relation to the yields of clone Avros 50 in the same plot. (Table XIX).

Clone Collection (Field 15. N)

The northern section of Field 15 contains a collection of 55 clones, some of historic interest, others which were little known when budding was done in 1931 and 1932. All of these clones are now being tapped and yields of the best clones are given in Table XIX. It will be noted that the yields of the proved clones are considerably higher than those of the Estate clones, none of which reaches a standard that would be considered for selection for planting at the present time.

Although the attempt to obtain valuable new clones by a method of mass selection on estates must be judged a failure it has been of considerable value in one direction. It has indicated fairly conclusively that little further advance can be expected from further selection among the mass of unselected seedling material in commercial plantations. If the yields of the clones in Field 15.S (Table XIX) are compared with the yields of the new clones from legitimate crosses (Table XXIV) it will be at once apparent that further advances must be sought in the study of legitimate seedling families and in new clones derived from them.

TABLE XIX. *Yields of new Clones from Estate Mother-Trees (Field 15. S) and Clone Collection (Field 15. N) (Yields of Clone Avros 50 are given in italics)*

Clones from Estate Mother-Trees					Clones from the Clone Collection				
Clone	Yield in lb. per tree				Clone	Yield in lb. per tree			
	1937		1938			1937		1938	
	Clone	Av. 50	Clone	Av. 50		Clone	Av. 50	Clone	Av. 50
R.R.I. 3	3.5	*2.4*	6.3	*3.7*	Av. 150	6.1	*3.1*	9.0	*4.4*
„ 24	6.5	*3.6*	6.5	*4.5*	„ 163	5.3	*2.5*	9.2	*3.7*
„ 28	4.2	*4.5*	6.3	*4.0*	P.B. 31	6.1	*3.2*	6.1	*4.5*
„ 63	5.6	*4.2*	5.9	*3.7*	„ 49	5.8	*3.5*	8.8	*4.4*
„ 88	4.8	*3.7*	6.8	*3.9*	„ 86	6.2	*3.8*	9.2	*6.1*
„ 99	5.4	*3.8*	6.8	*4.5*	„ 123	9.1	*3.1*	9.6	*5.4*
„ 103	7.0	*4.4*	6.2	*5.3*	„ 155	7.1	*2.8*	9.8	*4.4*
„ 107	5.4	*3.8*	7.8	*4.4*	B.D. 2	5.0	*2.4*	6.7	*5.0*
„ 137	6.4	*3.7*	4.2	*4.2*	P.E. 26	7.1	*2.3*	10.0	*4.8*
„ 138	5.9	*3.3*	6.0	*4.4*	B.R. 2	3.9	*2.9*	6.1	*6.1*
„ 139	6.3	*3.8*	4.5	*4.2*	T.K. 14	5.5	*3.4*	8.0	*5.3*
„ 140	6.3	*5.0*	6.3	*4.8*	Lun. N	7.4	*3.9*	9.0	*3.9*
„ 142	6.8	*3.5*	7.5	*4.4*	R.A. 22	9.2	*2.9*	10.7	*4.5*
„ 147	7.7	*4.1*	7.6	*4.0*	„ 23	10.1	*3.8*	10.0	*5.9*
„ 162	6.3	*4.1*	6.5	*3.1*	Pil. B. 16	4.4	*3.6*	8.0	*5.3*
„ 163	6.5	*4.4*	5.6	*5.5*	Glen. 11	5.2	*2.4*	8.8	*4.4*
„ 186	—	—	6.1	*3.8*	K. 80	5.4	*3.3*	8.1	*4.3*
„ 207	—	—	5.4	*3.9*	Sab. 3	—	—	5.1	*3.0*
„ 235	—	—	5.0	*3.3*	Rub. 424	—	—	6.5	*4.0*

Notes. Each clone is represented by a single plot containing 20 buddings of the clone and 10 of Avros. 50 for comparison. The apparent drop in yield of certain clones in the above table is accounted for by the inclusion of additional, smaller trees which came into tapping during 1938. All trees tapped are included in the averages.

Clones R.R.I. 1 to 163 were budded in late 1931.
Clones R.R.I. 164 to 235 were budded in late 1932 to April 1933.
Clone Collection budded in late 1931 to April 1932.

Selection of new Clones on Estates

During 1930 assistance was given to a number of estates who wished to lay out small areas to test the value of buddings made from outstanding high-yielding trees on their own properties. Subsequently the Institute assisted in the testing of the clones established in these areas and the results of tests on promising new clones on three estates are given below. Tapping was commenced in May 1936 when the trees were six years old.

Table XX. *Yields of New Clones on three Estates.*

Estate	Clone	No. of Trees	Yields in lb. per Tree per year		
			6 years	7 years	8 years
W	Avros 50	21	4.8	7.1	9.6
	W.A. 9	21	8.1	11.3	14.0
	K. 61	13	5.2	7.5	9.9
K	Avros 50	22	3.8	5.4	7.6
	K. 61	22	8.8	12.0	14.3
	K. 41	19	8.3	8.1	9.6
S	Avros 50	38	4.7	5.0	5.8
	Ss. 5	37	12.2	13.2	17.0

Clones W.A. 9, K. 61 and Sg. 5 appear promising and records will be continued on these clones.

Breeding Investigations

The programme of breeding work, recommenced in 1937 after a lapse of six years, was continued in 1938. During the flowering season February to May 1938 crosses were made between some of the new clones of the 500-Series (Table XXIV) and with clones Pilmoor B. 84, Tjirandji 1 and Tjirandji 16.

The clones used with their parentage, where known, are given below.

Clone	Parentage	Clone	Parentage
R.R.I. 500	B.84 × A.44	R.R.I. 509	A.44 × Lun.N
R.R.I. 501	A.44 × Lun.N	R.R.I. 511	A.44 × B.16
R.R.I. 504	A.44 × Lun.N	Pilmoor B.84	—
R.R.I. 506	B.84 × A.44	Tjirandji 1	—
R.R.I. 507	B.84 × A.44	Tjirandji 16	—

A complete list of crosses made with the results obtained is presented in Table XXI.

TABLE XXI. *Results of Hand-pollination 1938*

No.	Cross	No. of Pollinations	No. of Fruits Harvested	Per cent Success	No. of Seeds Planted	No. of Seeds Germinated	Per cent Germination
1	500 x 501	15	—	—	—	—	—
2	501 x 500	32	3	9.4	9	9	100
3	500 x 504	62	—	—	—	—	—
4	504 x 500	233	52	22.3	156	128	82.0
5	500 x 506	4	—	—	—	—	—
6	500 x 509	14	—	—	—	—	—
7	509 x 500	52	1	1.9	3	3	100
8	511 x 500	162	7	4.3	21	17	80.9
9	B. 84 x 500	38	1	2.6	3	3	100
10	500 x Tj. 1	32	—	—	—	—	—
11	Tj. 1 x 500	171	10	5.8	30	18	60.0
12	501 x 504	27	—	—	—	—	—
13	504 x 501	70	—	—	—	—	—
14	501 x 506	81	11	13.6	33	26	79.0
15	501 x 509	154	3	1.9	9	9	100
16	501 x 511	109	15	13.9	46	45	98.0
17	501 x B. 84	75	4	5.3	12	12	100
18	B. 84 x 501	59	2	3.4	6	5	83.3
19	501 x Tj. 1	117	11	9.4	33	33	100
20	Tj. 1 x 501	96	1	1.0	4	4	100
21	504 x 506	42	5	11.9	15	15	100
22	504 x 509	179	19	10.6	57	55	96.4
23	509 x 504	3	—	—	—	—	—
24	504 x 511	82	28	34.1	88	88	100
25	511 x 504	2	—	—	—	—	—
26	504 x B. 84	102	21	20.6	63	57	90.4
27	504 x Tj. 1	106	27	25.5	81	81	100
28	Tj. 1 x 504	167	6	3.6	19	16	84.2
29	509 x 506	27	—	—	—	—	—
30	511 x 506	42	—	—	—	—	—
31	Tj. 1 x 506	132	—	—	—	—	—
32	511 x 509	145	6	4.1	18	17	94.4
33	509 x B. 84	17	1	5.9	3	3	100
34	Tj. 1 x 509	123	3	2.4	9	8	88.8
35	511 x B. 84	100	3	3.0	9	8	88.8
36	B. 84 x 511	7	—	—	—	—	—
37	511 x Tj. 1	73	1	1.4	3	3	100
38	Tj. 1 x 511	96	14	14.5	44	44	100
39	B. 84 x Tj. 1	40	—	—	—	—	—
40	Tj. 1 x B. 84	374	31	8.3	97	87	90.0
41	Tj. 1 x Tj. 16	226	20	9.0	62	52	84.0
42	Tj. 16 x Tj. 1	5	—	—	—	—	—
43	Tj. 1 x 507	247	19	7.7	58	37	64.0
44	507 x B. 84	9	—	—	—	—	—
45	B. 84 x 507	94	—	—	—	—	—
	Total	4,043	325	8.0	987	883	89.5

Clone R.R.I. 504 would appear to be a fertile female parent, 814 crosses made with seven males on 504 as the female gave 152 fruits or 18.5 per cent success. The cross 504 × 511 gave 34.1 per cent of mature fruits and 88 seeds all of which germinated.

Clone Tjirandji 1 gave approximately 7 per cent success when used as a female parent and over 10 per cent as a male parent. It was observed during the 1937 pollination season that the female flowers of B. 84 aborted freely and as a result B. 84 proved a poor female parent.

During 1938 it was found that the clones of which Clone Pilmoor B. 84 is one of the parents show a high degree of sterility when crossed together or when "back-crossed" to B. 84.

During the 1938 season 238 pollinations on B. 84 as a female parent produced only 3 fruits. When used as a pollen parent, 677 pollinations made with B. 84 pollen gave 60 mature fruits. It is interesting that R.R.I. 500, a child of B 84, appears to have inherited this character; of 127 pollinations made on female flowers of R.R.I. 500 not one set fruit, whilst 688 crosses made with pollen from R.R.I. 500 set 74 fruits.

Legitimate Seedling Families obtained by Hand-pollination

The yields during 1938 of the families of crosses made from 1928 to 1931 are summarised in Table XXII. There is little to add to the observations made in previous years. It will be noted that many of the most promising families are derived from Clone Pilmoor B. 84. The families B. 84 × B. 58 and B. 84 × D. 65 have shown noteworthy increases in yield during 1938. Buddings derived from seedling mother trees of these families are very promising and a number of them will probably be included in a further series of new clones following R.R.I. 522 after further observation during 1939.

The seedlings in the 1929 series were planted at about the same time as the budded trees in Field 5. Strict comparison is not possible as there is no means of ascertaining to what extent differences in yield may be due to soil conditions. Nevertheless, conditions are believed to be roughly comparable, from study of the soil in the two fields, and the rates of growth of the trees have been similar from planting. (Table XXIII).

TABLE XXII. *Yield of Legitimate Seedling Families in 1938*

Parents	1928 Series Age on 1.1.38 8 years 8 months		1929 Series Age on 1.1.38 7 years 9 months to 8 years 3 months		1930 Series Age on 1.1.38 6 years 9 months to 7 years 3 months		1931 Series Age on 1.1.38 6 years 3 months	
	No. of Trees	Mean Yield in lb. per tree	No. of Trees	Mean Yield in lb. per tree	No. of Trees	Mean Yield in lb. per tree	No. of Trees	Mean Yield in lb. per tree
A. 8 & A.44	6	10.2						
A. 8 & B.58	21	11.0						
A.44 & B.58	13	13.6	64	10.7				
A.44 & D.61	73	12.7	137	10.9				
A.44 & B.16	30	15.8	101	10.4				
A.44 & B.84	8	16.4	74	13.0	82	9.5		
B.58 & D.61	8	10.2					123	7.3
B.58 & B.16	12	13.9	7	13.9				
D.61 & B.16	4	8.3	13	5.3			40	6.9
A.44 & B.50			19	8.7				
D.65 & A.44			4	6.4	20	5.6		
B.50 & B.58			24	7.8				
B.58 & B.84			13	14.4	22	8.8	3	15.0
B.84 & D.61			48	10.6				
B.84 & B.16			37	11.8				
D.65 & B.16			7	9.5	1	4.8		
A.44 & B.65					15	5.8		
D.65 & B.84					41	8.3		
B.50 & B.84					16	8.9		
B.58 & D.65					11	4.0		
B.58 & B.65					2	6.4		
C.72 & B.84			5	15.4				
B.58 & C.72			3	13.9				
B.90 & B.16					10	4.5		
B.50 & E.95			3	6.8				
B.95 & A.44	9	11.9						
A.44 & Lund. N			17	14.4				
B.84 & Lund. B					5	6.3		
Lun. K. & Lun. N			2	12.2				
A.44 selfed			1	9.3	5	4.3		
B.58 & B.90			3	4.0				
D.65 & D.61					1	3.8	74	7.9
B.11 & D.65					4	1.8		
D.61 & G.1							28	5.7
B.84 & G.1							13	8.2
B.58 & G.1							4	3.0
Mean yield for all families 1936		8.6		6.1		3.3		
1937		10.9		9.2		5.2		4.7
1938		12.4		10.5		5.9		7.7

TABLE XXIII. *Comparison of Yields of Buddings of the best Clones with Seedlings of the best legitimate Families and New Clones from Crosses*

Clone or Seedling Family	Date of Planting	No. of Trees in Test	Yield in pounds per Tree per year			
			1935	1936	1937	1938
Clones						
Tjirandji 1 ...	Nov. 1929	28	6.2	9.0	12.7	16.3
Pil. B. 84 ...	„ „	26	4.8	7.0	10.0	12.2
All Clones		—	4.3	6.1	7.9	10.5
Seedlings						
B. 84 x A. 44 ...	Oct.—Nov. 1929	31	6.1	9.5	13.3	14.4
B. 58 x B. 84 ...	„ „ „	14	5.7	8.3	10.8	14.4
All Crosses		—	5.0	7.3	10.3	12.2
New Clones from crosses						
R.R.I. 500 ...	Oct. 1930	3	—	13.1	15.9	20.9
R.R.I. 502 ...	„ „	3	—	9.1	8.7	13.5

Bearing in mind that the above comparison is of necessity a very rough one, it would appear that the best legitimate seedling families may be quite up to the standard of the best of the older proved clones. But the clones in the last section of the table, which have been developed from the best mother-trees of the seedling families, give promise of higher yields than the crosses or the best of the older proved clones.

NEW CLONES FROM LEGITIMATE SEEDLINGS

The yields of the new clones of the R.R.I. 500 series are summarised in Table XXIV. The notes on these clones given on p. 113 of the report for 1937 need a few additions.

TABLE XXIV. *Yield of the first Selection of Clones made from Legitimate Seedlings*

Clone	Origin of Mother-Tree	Yield in lb. per Tree per annum		
		1936	1937	1938
500 (1)	B. 84 x A. 44	13.1	15.9	20.9
501	A. 44 x Lund. N	9.3	18.2	26.3
502 (1)	B. 16 x A. 44	9.1	8.7	13.5
503	A. 44 x B. 16	8.1	8.9	11.8
504	A. 44 x Lund. N	8.6	13.8	12.4
505	A. 44 x Lund. N	7.1	10.4	13.6
506	B. 84 x A. 44	7.6	13.8	16.1
507	B. 84 x A. 44	6.5	9.0	11.4
508 (1)	B. 16 x A. 44	6.5	8.2	8.9
509	A. 44 x Lund. N	9.2	12.6	11.4
510	B. 58 x A. 44	7.9	10.2	9.7
511	A. 44 x B. 16	8.1	13.3	14.8
512 (2)	B. 84 x A. 44	6.0	10.3	12.3
513	B. 16 x A. 44	8.0	19.2	16.5
514	A. 44 x B. 58	7.1	14.6	15.1
515	A. 44 x D. 61	6.4	13.9	17.0
516	B. 84 x A. 44	5.1	10.4	10.5
517	B. 84 x A. 44	4.8	8.5	5.1
518	D. 61 x A. 44	5.2	11.4	14.8
519	A. 44 x B. 16	6.3	10.5	13.7
520	A. 44 x B. 16	5.0	10.1	13.6
521	A. 44 x B. 58	5.2	9.4	7.5
522	B. 84 x A. 44	6.3	12.4	11.8

Notes:

(1) Clones 500, 502 and 508 were budded in the field in November 1930, and were tapped from July to December 1935.

(2) Clone 512 was budded in the field in June 1932.

The remaining clones were budded in the field in October to November 1931, so that the majority of the buddings whose yields are recorded above were only 7 years old in December 1938.

It will be observed that for most of the clones the increase in yield during the third tapping year is small; some clones show a slight decline in yield. Whilst weather conditions during last season were unfavourable and the depressing effect of dry weather on yield is very noticeable on poor sandy soils, the failure to increase in yield may be accounted for in part by other factors. All the clones in this first selection are descendants of clone Pilmoor A. 44 and they may have inherited a characteristic quality of A. 44, *i.e.* the capacity to give high yields when young but a tendency to show small increases in yielding capacity with increasing age.

Yields of Illegitimate Seedlings derived from High-yielding Clones

In Table XXV data from tapping tests on a number of different plantings of clonal seedlings on the R.R.I. Experiment Station have been collected. The first group includes illegitimate seedlings planted in the selection fields along with the legitimate crosses described in foregoing sections of this report. The second group includes plantings of illegitimate clonal seedlings from a number of different sources.

Table XXV. *Yields of Illegitimate Clonal Seedlings from various Plantings on the R.R.I. Experiment Station*

Origin of Family	Date of Planting	No. of Trees in test	Yield in lb. per Tree per annum			
			1935	1936	1937	1938
Pil. A. 44	Apr. 1929	156	5.8	8.0	9.8	11.8
„	Nov. 1929	60	3.8	5.9	8.8	9.2
„	Apr. 1930	26	3.6	5.6	8.8	8.7
Pil. B. 58	Apr. 1929	76	4.6	6.4	8.3	10.5
„	Nov. 1929	67	2.9	5.0	7.5	7.5
„	Apr. 1930	16	3.0	5.0	8.7	7.7
Pil. B. 84	Apr. 1929	21	5.6	8.2	11.6	15.8
„	Nov. 1929	148	4.0	7.0	10.5	11.0
„	Apr. 1930	11	2.5	5.2	9.0	7.2
Pil. D. 65	Apr. 1930	41	2.3	3.6	6.7	7.7
„	Nov. 1932	14	—	—	—	4.4
P.B. 8	Dec. 1931	18	—	—	6.4	10.1
„ 24	Dec. 1931	13	—	—	5.3	8.1
„	Nov. 1932	14	—	—	—	5.5
„ 49	Dec. 1931	19	—	—	7.7	11.8
„ 25	Nov. 1932	30	—	—	—	5.1
„ 86	Dec. 1931	41	—	—	6.5	10.7
Glen. 1	Dec. 1931	23	—	—	3.2	5.3
„	Nov. 1932	29	—	—	—	3.8
Sab. 24	Dec. 1931	17	—	—	5.9	9.6
„	Nov. 1932	77	—	—	—	5.0
S.R. 9	Dec. 1931	25	—	—	6.4	10.6
„	Nov. 1932	59	—	—	—	5.5

Although the yields of the illegitimate seedlings of the Pilmoor clones are lower than those of the legitimate crosses they are nevertheless quite good. For example, illegitimate seedlings of clone Pilmoor B. 84, planted in November 1929, have given yields which are almost equivalent to those of the budded trees of B. 84 planted as budded stumps in Field 5 at the same time (Table XXIII).

The early yields of the seedlings derived from the Prang Besar clones 8, 49 and 86 and from clones Sabrang 24 and Sungei Reko 9 are also very promising.

Seedlings from Isolated Seed Gardens

The regular tapping and recording of yields of the families of seedlings from the Tjikadoe isolated seed gardens planted in

Field 2 on the Experiment Station was continued during the year. The records are summarised in Table XXVI.

TABLE XXVI. *Summary of Yield Records of Families of Seedlings from the Tjikadoe Isolated Seed Gardens.*
(Age 1938—9¼ to 10¼ yrs.)

Family	Number of Trees tapped				Yield in lb. per Tree			
	1935	1936	1937	1938	1935	1936	1937	1938
1	9	9	9	9	6.6	10.5	12.2	13.6
2	13	12	12	11	7.0	11.6	14.4	20.4
3	9	10	10	11	4.0	7.2	8.5	13.0
4	8	10	11	11	3.2	5.2	7.3	10.0
5	10	13	14	13	2.9	5.1	4.6	6.7
6	8	11	11	10	6.3	9.1	12.3	19.1
7	12	12	12	12	6.5	12.2	14.4	20.2
8	9	11	11	11	3.7	6.2	7.8	10.4
9	4	5	5	5	5.4	9.6	14.1	20.8
10	10	9	8	7	9.6	17.4	15.5	16.6
11	10	9	9	9	3.4	6.6	6.5	4.5
12	7	7	7	7	4.5	9.0	9.5	14.5
13	6	9	8	6	5.5	5.8	6.7	11.0
14	6	6	6	6	4.1	9.4	11.9	18.7
15	14	13	13	13	7.0	11.1	14.3	20.4
16	4	7	6	6	3.6	4.7	7.0	8.8
17	9	10	8	9	8.4	12.2	21.7	26.4
18	10	10	10	10	4.3	7.2	9.2	13.2
19	12	13	13	13	4.6	7.1	8.6	11.8
20	15	15	11	13	9.2	16.8	18.4	23.7
21	6	8	8	8	11.3	9.6	12.0	15.8
22	9	9	9	9	5.6	10.8	14.0	24.8
23	9	9	9	9	5.2	7.7	9.4	14.0
24	9	10	10	11	5.5	8.7	11.5	16.3
25	7	7	7	8	3.1	3.7	5.2	10.0
All trees	225	244	237	237	5.5	9.0	11.1	15.4

With the exception of family 11, all families have shown a good increase in yield. Seven families have shown mean yields of over 20 pounds dry rubber per tree in the 4th tapping year. Family 22 is particularly interesting; although the early yields of the trees of this family were near the average figure for the whole collection, the yield in 1938 rose to the high figure of 24.8 pounds per tree, nearly 10 pounds above the average. These results provide interesting examples of the differences which may be found between different seedling families in the way in which high-yielding qualities may develop with increasing maturity. They serve to emphasise the danger of forming a hasty judgment of the ultimate value of any single family of seedlings on the results of early tests. The yields of trees of family 21 illustrate the opposite side of the picture, for the initial yields of this family were more than double the average of the whole collection, whereas the yields in the fourth tapping year are near the average for the collection.

Early Determination of Yielding Qualities of Seedlings

The relationship between yields of trees during the 4th year of normal continuous tapping ($\frac{1}{2}$S, a.d.) and the yields obtained during short periods of test-tapping, commencing at $3\frac{1}{4}$ years from planting, are presented in Table XXVII. This investigation has been in progress for seven years and the results have been published regularly in previous reports. The trees used in this study are the mixed collection of clonal seedlings from the Tjikadoe Isolated Garden.

Table XXVII. *Relationship between Yields at Test-tapping and Yields obtained under Normal Continuous Tapping*

No. of Test-tapping	Age of Trees years	Coefficient of correlation between Yield of Test and Total Yield			
		$6\frac{1}{4}$—$7\frac{1}{4}$ years	$7\frac{1}{4}$—$8\frac{1}{4}$ years	$8\frac{1}{4}$—$9\frac{1}{4}$ years	$9\frac{1}{4}$—$10\frac{1}{4}$ years
1	$3\frac{1}{4}$	+0.77	+0.68	+0.58	+0.46
2	$3\frac{3}{4}$	+0.75	+0.76	+0.64	+0.53
3	$4\frac{1}{4}$	+0.85	+0.77	+0.69	+0.69
4	$4\frac{3}{4}$	+0.83	+0.86	+0.65	+0.54
5	$5\frac{1}{4}$	+0.80	+0.80	+0.70	+0.59
6	$5\frac{3}{4}$	+0.85	+0.83	+0.74	+0.64

The gradual decrease in the values of the coefficients of correlation between the yields of the early tests and subsequent yields has continued. Although the relationship is still highly significant and in general the statement that high yielders remain good and poor yielders remain poor is fully supported, it appears that the agreement between the early test-tapping yields and later yields becomes less close as the trees mature.

A factor which may have some bearing on this is that the tapping cuts are now approaching the renewed bark of the original test-tapping panel. Differences in rate of renewal and quality of renewed bark may have contributed towards the differences which have operated to lower the value of the coefficients of correlation. Brown-bast has also made its appearance and differences in susceptibility of different trees to this malady may have influenced the results.

IV. Physiological Investigations

Nutrition: Pot-Culture Experiments

The object of these experiments is the study of the effect of deficiencies of nitrogen, phosphorus, potassium, calcium and magnesium on the growth and metabolism of Hevea. The leaf symptoms associated with the deficiencies of these essential elements will, it is hoped, be of assistance in the diagnosis of symptoms of malnutrition in the field.

The planting material which consists of buddings of clone Tjirandji 1 on one-year-old clonal seedling stocks from clone B.D. 10 was planted in sand cultures in June 1938 and the first addition of nutrients was made a month after planting.

The sand obtained from the bed of a stream at the R.R.I. Experiment Station was passed through a 3-mm. sieve and the soluble impurities removed by washing in several changes of water.

Sensitive "spot" tests failed to reveal the presence of soluble impurities with the exception of calcium. A positive reaction was obtained for calcium which on chemical analysis was found to amount to less than 0.1 per cent of the oven-dried sand. The water-holding capacity of the sand is satisfactory owing to the high percentage of small sized particles (66 per cent between 1 mm. and 0.2 mm. and 11 per cent under 0.2 mm.)

The technique followed was, with a few slight modifications, that used by Wallace at the Long Ashton Research Station in pot-culture work with fruit trees.

The budded stumps after complete removal of lateral roots and pruning of the tap root at one foot from the "collar" stood overnight in a solution of Hortomone "A" and planted

singly in glazed earthenware pots (18 in. diam.) each containing 180 lb. of quartz sand.

The plants were graded according to weight and were divided into six series of fifteen plants each:

Series	A	Complete	Nutrient	solution.				
„	B	Nitrogen	omitted	from	the	complete	Nutrient	solution.
„	C	Phosphorus	„	„	„	„	„	„
„	D	Potassium	„	„	„	„	„	„
„	E	Calcium	„	„	„	„	„	„
„	F	Magnesium	„	„	„	„	„	„

In the deficient series the omitted cations are replaced by sodium and the omitted anions by sulphate in equivalent amounts.

In addition to the above a seventh series of ten plants (Series G) received complete nutrient solution with omission of the "minor" elements manganese, zinc, copper and boron.

The nutrient solutions are applied at the rate of 1,000 c.c. to each pot once a week after adjustment of their pH to approximately 5.0 by addition of dilute sulphuric acid.

All pots are drained every other day and the drainage solution made up to one litre with tap water and returned to the surface of the sand.

The pots are leached through monthly with tap water.

Symptoms of yellowing and mild scorch observed in all treatments at first (and thought to be caused by bright sunlight and high temperature) were later suspected to be due to potash shortage, and the concentration of that element, which had been reduced to 176 p.p.m., was brought back to the level of 232 p.p.m.

Owing to the very slow growth and premature leaf abcission in the nitrogen-omitted series it was considered that complete omission of any single major element from the nutrient solution was too drastic and that one-tenth the amount of that element contained in the complete solution should be added to that deficient solution.

The observations recorded below were made during the first six months after planting in sand culture and as it is possible that the food reserves of the stock have not been entirely used up, the leaf symptoms showing at this early stage may be considerably modified as the experiment progresses.

Complete Nutrient—Series A

The leaves were light green to green at the third month. Three months later a few leaves on some plants showed a faint yellowing between the veins and scorch of the extreme tip. The plants were still in full leaf. Lateral shoots had developed on two plants of the series.

Nitrogen omitted — Series B

Three months after planting when the scion had made about 35 cm. of linear growth leaves on about 50 per cent of plants became lighter green. As the treatment continued the leaves of the second whorl produced after extension growth turned yellowish green and had scorched tips. There was no leaf abcission until the fifth month when a few yellowish leaves on some of the plants were shed. By that time the bark of the shoot and petioles had become yellowish green and growth in length and diameter had almost ceased. Only one short slender lateral shoot had developed on one plant.

Phosphorus omitted—Series C

A few leaves on some plants had turned light green to yellowish green by the end of September. The leaves after six months of the treatment were dull green to green with slight tip scorch but no very marked foliar symptoms due to the deficiency could be observed. The plants were still in full leaf and lateral shoots had developed on three plants.

Potassium omitted — Series D

Leaves on a few plants were light green to yellowish green with necrotic spots and tip scorch three months after planting. Three months later a few leaves on 60 per cent of plants showed yellowing between the veins where the green colour was changed to a dull yellow and all mature leaves were effected with tip scorch. The older leaves were yellowish, the chlorosis being presumably due to translocation of the available potassium to the younger leaves. The plants were still in full leaf and short lateral shoots had developed on six plants.

Calcium omitted — Series E

Few yellowish green leaves were observed at the end of the third month. No well defined symptoms could be observed at the sixth month but some older leaves were dull green to yellowish green with scorch of the extreme tip. Growth was better than in the other deficient series and lateral shoots had been produced on seven plants.

Magnesium omitted — Series F

Leaves were light green at the third month from planting. Three months later it was observed that the leaves of the second storey of the terminal shoot and those of lateral shoots were

light green except along the midrib and larger veins. The light green colour gradually changed to yellow as the leaves approached maturity but the narrow portion of the leaf lamina abutting on the midrib and veins retained its normal green colour. No browning or "blotching" of the affected portions had occurred at the time of the last inspection, but scorch of the extreme tip of a few leaves was observed. The plants had made good growth and lateral shoots had developed on eight plants.

Minor Elements omitted — Series G

The appearance of the foliage at the sixth month was much the same as in Series A.

At the end of the sixth month the plants of Series E (Calcium omitted), Series F (Magnesium omitted) and Series A (Complete Nutrient) had made the best shoot growth. The plants of Series D (Potassium omitted) and Series C (Phosphorus omitted) came next in that order whilst plants of Series B (Nitrogen omitted) were smallest of all.

The data for shoot growth in the different series are tabulated below.

Treatment	Series	Average length of Shoot Growth per Plant	Average diameter of Main Stem at 3 inches from Union
Calcium omitted ...	E	663.8 mm.	13.5 mm.
Magnesium „ ...	F	609.2 „	13.4 „
Complete Nutrient ...	A	579.9 „	13.1 „
Potassium omitted ...	D	554.6 „	12.9 „
Phosphorous „ ...	C	502.1 „	12.5 „
Nitrogen „ ...	B	460.2 „	11.4 „

Increased leaf size and shoot growth of the calcium and magnesium-deficient plants have also been observed by Wallace in the early stages of growth of apple trees in sand culture at the Long Ashton Research Station and the effect is attributed to the higher potassium-content of the plants of these two deficient series.

Treatment with Growth Promoting Substances for the Stimulation of Bark Renewal in Hevea

The experiments described in the Report for 1937 have been continued.

(A) Beta-indolyl-acetic acid (heteroauxin) in hydrous lanolin at concentrations of 1 in 1,000, 1 in 5,000, 1 in 50,000 and 1 in 500,000, applied to the cambial tissue after stripping the "bark," has produced no significant increase in the thickness of renewed bark one year after treatment.

It is thought that lanolin owing to its tackiness prevents free access of oxygen to the actively respiring meristematic tissue thus slowing down the rate of cell division.

A more permeable "solvent" such as emulsified vegetable oil will be used in a further experiment and the treatment will consist of weekly applications of the mixture of growth-promoting substance and oil to the tapped surface about one inch above the cut.

(B) The joint experiment with the Pathological Division on the effect of palm oil and mixtures of fungicidal oil and palm oil on bark renewal mentioned in the Report for 1937, was completed during the year and showed highly significant differences in thickness of renewed bark between all treatments where palm oil was used on the one hand, and the treatment where no palm oil was used with the fungicide and the untreated control on the other.

TABLE XXVII. *Effect of Palm oil on the initial rate of Bark Renewal on old Trees*

Treatment	Increase in Thickness of Renewed Bark in mm. at 7½ months after Treatment				
	1	2	3	4	Mean
Palm oil alone	4.05	2.60	3.68	3.45	3.45
Palm oil + A	4.33	2.66	3.18	3.56	3.43
Palm oil + B	4.11	2.88	4.40	3.50	3.72
Palm oil + C	4.32	3.10	4.26	3.30	3.75
Fungicide alone	2.11	1.34	2.99	2.20	2.16
No treatment	1.59	1.78	2.61	2.37	2.09

This work will be continued on trees of different ages and the value of other vegetable oils, known to contain hormone substances in physiological concentrations, will be investigated in this connexion.

V. Ecological Studies

Cultivation of Rubber Trees in Association with Indigenous Plants and Leguminous Covers

The experiment in progress in Field 27 at the Experiment Station has been continued, and a brief account of the conditions obtaining at the end of the fourth year from planting is given below. There have been only minor changes since the last report was published (Annual Report for 1937, p. 120-122). The systems of cultivation included in this study are:—

(1) Natural covers only with minimum control

(2) Natural covers controlled by slashing, at a height of four feet, at intervals of six months

(3) Similar to (2) but all ferns are removed

(4) Leguminous bushes with *Desmodium ovalifolium*

(5) Leguminous creepers

Under system 1, many of the tree species previously recorded, *Endospermum, Anthocephalus* and *Commersonia* have practically disappeared; they appear to be unable to tolerate severe lopping. With their disappearance there has been a marked increase in creeping fern *(Nephrolepis)* and wild ginger (*Hornstedtia*) and a varied population of shrubby species still survives, forming a mixed association growing to a height of about 10 feet. Above these, vigorous growth of "mahang," species of *Macaranga,* and *Mallotus* continues. These species tolerate frequent severe lopping.

Where natural covers have been slashed repeatedly without selective treatment, system 2, many of the species found under system 1 persist but the dominant species are wild ginger and creeping fern. Wild fig *(Ficus alba)* has developed abundantly and thrives well despite repeated slashing. This species fruits early, probably in its first year, and seed is dispersed by birds. The association *Ficus—Hornstedtia—Nephrolepis* appears to be relatively stable; all appear to be shade-tolerant and together they may form a complete ground cover under the shade of the rubber trees.

Under system 3, where ferns are removed, the repeated slashing appears to check the development and spread of wild ginger and the ground cover is noticeably less effective than in system 2. On the steeper slopes erosion has been fairly severe. In the more open situations the ephemeral weeds *Ageratum* and *Erigeron* frequently occur and young plants of *Trema virgata* may thrive for a short period.

The plots planted with a mixture of the shrubby legumes, *Crotalaria, Tephrosia* and *Leucaena* now contain little but the latter species with a heavy ground cover of *Desmodium ovalifolium*. The latter species was planted two years previously when it was apparent that the shrub legumes were quite ineffective in checking erosion. *Desmodium* has been seriously attacked by eelworm.

In the plots planted with creeping legumes, *Pueraria* has failed to maintain its dominance and *Centrosema* has made vigorous new growth in areas where *Pueraria* was the only visible cover about one year previously. No manuring has been done in this experiment but it may be necessary to introduce manuring treatment during the current year in an attempt to retain the cover. General weakening of all species is apparent but the regeneration of *Centrosema* with the decline in the vigour of *Pueraria* may be further encouraged by suitable fertiliser treatment.

Careful records of the relative costs of maintenance under the different methods of treatment have been taken and, regarding system 5 with creeping legumes as the standard or control method, the relative costs of the other treatments have been as follows: Natural covers with minimum control 21 per cent higher cost of maintenance; natural covers regularly slashed without selection 2 to 5 per cent less than the control; where ferns are removed the costs have been 15 per cent higher, and under shrub legumes maintenance charges were increased by 17 per cent. These figures are based on total upkeep costs over a period of four years.

Further Experiments on Estates

Under the scheme for the development of experimental areas on estates five further experimental areas have been established on different soil types to continue and extend the study described above. Botanical surveys have been made on three of these areas during the year.

Eradicating Jungle Trees by Poisoning

During the year an experiment was commenced on an area of 30 acres on the Experiment Station in which a method of developing and planting new jungle areas without felling and burning is being studied. By a method of frill-girdling and poisoning with a solution of sodium arsenite the jungle trees were killed without felling. Sufficient clearing of undergrowth was done to lay out planting lines and seedling rubber stumps were planted at a density of 360 plants per acre (interval 22 feet by 5½ feet). Except for occasional clearing of the planting rows during the first six months in order to give the rubber seedlings fair conditions

for early establishment there has been no further expenditure on cultivation. Planting was completed in May 1938 and by the end of the year the rubber seedlings showed excellent growth and losses had been negligible. Young stump plants appear to develop as vigorously as the regenerating jungle species during the early stages of this experiment.

We wish to record our indebtedness to the officers of the Forest Research Institute for their interest in this experiment, in particular to Mr. A. B. Walton who has been responsible for many of the suggestions adopted in planning the experiment. His assistance in the preparation of the area for planting and his continued interest in the progress of this experiment are greatly appreciated.

VI. **Field Experiments on the R.R.I. Experiment Station**

The undermentioned additions are made to the schedule of experimental areas for botanical work.

Field	Area acres	Description of Experiment	Date of Commencement
34	40	Prepared for selection work for planting with legitimate seedlings and new clones from crosses.	Planted Sept.-Oct. 1938
35	30	Poisoning of jungle. Comparison of Clonal seedling families for yield and as stocks for budding.	Planted April-May 1938
36	2	Experimental nursery developed in collaboration with Soils Division. Effect of nursery manuring on budding operations.	Planted Sept. Seedlings Dec. Budded stumps

VII. **Field Experiments on Estates**

The first restriction period, during which the scheme of experimental planting operated, terminated at the close of 1938, and during this final year 731 acres of jungle land were approved making a final total of 8,103 acres planted under experiments out of a permissible quota of 8,177 acres.

In this Division's Report for 1937 it was indicated that the experimental areas thus made available on estates in all parts of the country were being utilised primarily for large-scale testing

of new planting material in conjunction with comparisons of various manurial, cultivation and planting methods. The extensions of 1938 have continued this policy, and a major part of the new area is to be used for trials of new clones, at present unproved for commercial planting, developed in the course of this Division's breeding programme.

Straightforward clone and clonal seed trials comprised an additional 260 acres; stock experiments 54 acres; a catch-crop experiment 50 acres; and a trial of four different methods of planting 73.27 acres. The balance was utilised by the Soils Division for an extension of their manurial and cover crop series of experiments.

Clonal Seed Trials

In these experiments, consisting of ten separate areas, in addition to three estates undertaking stock experiments, the R.R.I. undertook to supply germinated seed of all seedling families to be tested.

The different families being compared fall into three categories:—(1) seed from commercial isolated seed gardens, (2) seed from polyclone areas on estates and at the R.R.I. Experiment Station, (3) seed from monoclone areas (selfed seed). In every case samples from each consignment were analysed on seed characters and the percentage of each mother-parent estimated.

A semi-permanent germination and packing shed was erected at the Experiment Station for effective organisation of this work, and a method of germination adopted which facilitated examination and removal of seed for packing as soon as the germination process reached the most suitable stage of development. Seed beds and packing room were housed under a single attap roof, and water supply laid on.

A note is shortly to be published on the method of germination used, in the belief that in modified form it may be found serviceable for estates when undertaking new plantings or replantings on a large scale. The essential feature of the method is the employment of coconut fibre mats as a cover for the seeds. By their use watering does not disturb or expose the seeds, and periodic inspection and removal as they germinate are greatly simplified.

Very satisfactory germination results were obtained and a total of 101,738 seeds was dispatched to estates during the main seeding season.

Supply of Budwood

The organisation of budwood supplies occupied a considerable amount of the time of both Institute and Experiment Station staff. Owing mainly to late planting and dry weather conditions several

of the areas planted in 1937 were not ready for budding in 1938 and consequently much of this work had to be postponed until the current year.

Field budding results have varied a good deal, and heavy supply-budding has in some cases been necessary. In order to obtain as uniform growth as possible, rendering future growth measurements comparable, stocks are not being cut back until a minimum of 80 per cent of points contain at least one successful budding.

Upkeep of Experimental Areas

Now that all areas have been opened up and planted, the main essential in upkeep is uniformity of treatment in all plots or blocks of plots. This aim has in certain instances been simplified by rearrangement of the lay-out so that topographical features such as ravines and swampy areas shall comprise single blocks thus permitting individual treatment without increasing experimental error. Variability due to pests and diseases is not, however, possible to control in such a manner and careful records have to be kept of their incidence.

Standardized planting schedules in which estates record the date and costs of all important operations were prepared and issued early in 1938 in connection with all experiments involving different cultural or manurial treatments.

Experimental Procedure

The lay-out of the later experiments has in every case been designed or approved by the Statistician with whom the Division collaborates on all statistical questions. On his advice extensive use is now being made of factorial systems of lay-out, and individual schemes to suit the particular problem and nature of the land take the place of the standardized forms initially employed.

In the majority of experiments with which this Division is concerned it is not proposed to institute systematic growth measurements or other quantitative observations before the rubber trees are three years old. Where field budding is employed records are kept of the percentage of buddable seedlings at certain periods, and later full budding records are taken. From the manurial experiments, where early growth records are of practical importance, the Statistician is able to determine what correlation exists between development of the young seedling or budding and its later history, but from the botanical standpoint the relative rates of growth of clones or seedling families less than three years old are not considered sufficiently valuable to justify accurate quantitative measurements and calculations being undertaken.

For the present, endeavour is centred on obtaining areas correctly laid out and planted with authentic material on sound commercial lines. When this object has been achieved in all areas the future experimental procedure can be organised and plans made for regular recording and tabulation of results.

Conclusions

The year 1938 was an unusually dry one in all parts of Malaya. This added materially to the difficulties of estate staffs, delaying the budding of 1937 areas and the planting of experiments begun in 1938. It affected particularly estates which were planting budded stumps. All areas were, however, fully planted by December 31st, 1938, as demanded by the Regulations, and we have pleasure in again acknowledging the keen co-operation shown by the Managers and Assistants of participating Estates.

VIII. **Advisory Work**

Correspondence

There was a very marked increase in the volume of enquiries dealt with by correspondence. The total number of enquiries was over 3,000, an advance of over 1,000 on the number in 1937. Of these written enquiries nearly 1,400 concerned the development of experimental areas on estates and the conduct of the new series of tapping experiments.

As in the previous year, the principal subject of enquiry has been choice of planting material; enquiries on tapping of budded trees have been steadily increasing in number. Much increased interest has been shown on the subject of clonal seed and enquiries on methods of laying out seed gardens in replanted areas were also numerous.

In connection with advisory work a number of circulars were prepared. A list of these is given below.

January 1938 (No. 1/38) Notes on the Development of Clones and Seedling Families of Hevea.

April 1938 (No. 2/38) "Wintering" in Clone Tjirandji 1.

April 1938 (No. 3/38) Notes on the Effects of Manuring in relation to the Operation of Budding Hevea.

April 1938 (No. 4/38) Notes on Sources of Supply of "Clonal Seed."

June 1938 (No. 6/38) Notes on Clone Glenshiel 1.

May 1938 (No. 7/38) Brief Recommendations for Thinning-out in Young Rubber Areas.

June 1938 (No. 9/38) Notes on Laying Out and Recording Field Experiments on Rubber.

July 1938 (No. 10/38) The "Testatex" method of Nursery Selection.

July 1938 (No. 11/38) Promising New Clones Developed in Sumatra and Java.

August 1938 (No. 13/38) The Stimulation of Root Formation in Hevea by treatment with Synthetic Growth-promoting Substances.

Estate Visits

A summary of visits made by members of the graduate staff, and the nature of the visits, is presented below:—

Member of Staff	Nature of Visits			
	General Advisory	Research (Experiment Station and Tapping Experiments)	Experimental Planting on Estates	Total
C. E. T. Mann ...	46	31	35	112
C. C. T. Sharp ...	13	69	20	102
E. R. Guest ...	2	128	1	131
E. D. C. Baptist ...	2	71	6	79
N. Wright ...	28	12	38	78
K. N. Kaimal ...	—	64	—	64
T. V. Vaidynathan ...	—	115	—	115
Totals ...	91	490	100	681

Interviews and Visitors

Two hundred and three visitors were received by the Division by appointment. Of these, 167 came to discuss planting programmes, choice of clones and related subjects; 36 interviews dealt with progress of new experimental plantings on estates.

Lectures

The following lectures were given during 1938:

Venue and Date	*Subject*	*Lecturer*
South Johore Branch Incorporated Society of Planters 29th April	"Choice of Clones for use in Replanting"	C. E. T. Mann
Bahau Branch Incorporated Society of Planters 28th April	"Tapping Systems"	C. C. T. Sharp
Malay Peninsula Agricultural Association, Penang, 9th May	"Choice of Clones for use in Replanting"	C. E. T. Mann
Kelantan Branch Incorporated Society of Planters 25th May	"Budding and Clonal Seedlings"	C. E. T. Mann
South Johore Branch Incorporated Society of Planters 7th May	"Tapping Systems"	E. R. Guest
Ulu Selangor and Tanjong Malim Branch Incorporated Society of Planters 29th July	"Problems of current interest on Estates"	C. E. T. Mann
South Kedah Branch Incorporated Society of Planters 25th August	"Problems of current interest on Estates"	N. Wright
Taiping Branch Incorporated Society of Planters and District Planters' Association 2nd September	"Problems of current interest on Estates"	N. Wright
Central Perak Branch Incorporated Society of Planters 5th September	"Problems of current interest on Estates"	N. Wright
Nilai Labu-Sepang Branch Incorporated Society of Planters 14th October	"Choice of Clones for use in Replanting"	C. E. T. Mann
North Johore Branch Incorporated Society of Planters 12 October	"Plant Breeding and Inheritance"	C. C. T. Sharp
Kuala Langat District Planters' Association 10th Nov.	"Problems of current interest on Estates"	N. Wright

Conferences

At the R.R.I. Planters' Conference held at the Institute on 29th July 1938, on "The Role of Cover Plants in Rubber Growing" a

paper on the "Botanical Study of the Succession of Covers in Young Rubber Areas," was presented by C. E. T. Mann and K. N. Kaimal.

Papers by C. E. T. Mann and N. Wright were also read at the Annual Conference of the Incorporated Society of Planters held at Penang on 24th September. These papers are included in the list of publications given below.

Tours

The Head of Division paid a visit to Java in August and early September, visiting the principal rubber research stations at Buitenzorg, Malang and Djember.

Publications

Experiments with Economic Tapping Systems (1) Part VI
C. C. T. Sharp *J.R.R.I.M.* **8** (1938) 83

Experiments on Tapping Systems
C. C. T. Sharp *J.R.R.I.M.* **8** (1938) 91

Notes on the Introduction of New Clones for use on Estates
C. E. T. Mann *J.R.R.I.M.* **8** (1938) 105

Experiments with Economic Tapping Systems (1) Part VII
C. C. T. Sharp *J.R.R.I.M.* **8** (1938) 241

Replanting—Choice of Clones for Replanted Areas
C. E. T. Mann and C. G. Akhurst *The Planter* Vol. 19 No. 2, p. 57, 1938

Recommendations on the Choice of Planting Material; Clones and Clonal Seedlings
C. E. T. Mann *The Planter* Vol. 19 No. 9, p. 441, 1938

Yields of Budded Rubber In Commercial Tapping
N. Wright *The Planter* Vol. 19 No. 9, p. 445, 1938

Botanical Study of the Succession of Covers in Young Rubber Areas
C. E. T. Mann and K. N. Kaimal Supplement to *The Planter* Vol. 19 No. 6, p. 10, June 1938.

C. E. T. Mann

Head of Botanical Division

Kuala Lumpur,

27th July, 1939

ANNUAL REPORT

PATHOLOGICAL DIVISION

Staff

In January Mr. Beeley was appointed Head of the Division but continued to be in direct charge of all work on pests and diseases above ground, on soils, nodule and latex bacteriology and on nematode pests.

Mr. Napper continued his services as Pathologist and was in charge of all research and advisory work on diseases and pests below ground level. His report on this section of the work for the year appears below under the titles of Root Disease, Termites and Cockchafer Grub investigations.

Mr. K. P. John, B.A. (Madras), Assistant Pathologist, was also on duty throughout the year and his help is again appreciated as routine culture work in connection with the distribution of cultures of nodule bacteria now demands considerable time.

Mr. H. C. Chuan the Institute's Artist and Photographer continued his valuable services assisted by Mr. Chan Tham Yew, who was appointed in February.

We again record our appreciation of the assistance given by the Asiatic Staff during the year under review.

We are grateful to the Government Entomologists for their generous assistance during the year in the identification of various pests and in consultation regarding entomological work in progress.

General Remarks on Progress of Research

Throughout the year it has again been necessary to devote much of our time and energy to general advisory work so that the time available for research has in consequence been considerably restricted. It is expected that the proposed appointment of an Entomologist will considerably relieve the pressure of advisory work and enable more rapid progress to be made along the lines of the programme of work.

Records of the advisory work for the year 1938 are given in detail in the appendix to the Director's report.

The wintering and refoliation season was very short and afforded little time for laboratory research work on *Oidium Heveae*. A report on the field investigations was prepared for publication.

Research on Mouldy Rot was confined to the testing of several proprietary fungicides and home-made mixtures some of which are of interest and are referred to more fully below.

Insect and rodent pests, owing to the more widespread adoption of legume or indigenous cover plants, have necessitated considerable work on control measures, which are referred to in detail below.

Researches on root disease fungi have been carried on by Mr. Napper, whose field experiments are now beginning to yield the instructive detail given in his section of the report.

Bacteriology has consisted almost entirely of work on the legume root nodule organisms and to a small extent on latex bacteria while no work on soils bacteria has been possible. The Division has prepared and supplied a large number of tubes of tested strains of Rhizobia for experimental inoculation of legumes in the field, and a method of multiplication of cultures on the estate for inoculation of large quantities of seed has been devised.

Root Disease Investigations (Mr. Napper)

Control in New Clearings

With the prospect of a limited amount of new planting in 1939, there was a marked revival of interest during the year in the control of root disease in young jungle clearings.

Control after planting has been closely studied for many years, and improved and well-tried methods of treatment are now available for general use Owing to the depressed state of the industry, however, there has been little opportunity since the present work began of studying the effects of clearing methods on the development of root disease in the subsequent plantation, and it is this aspect of the problem which is most in need of investigation at the present time, particularly in view of recent changes in policies of clearing and soil management, and the wider variety of clearing methods which are now in use. Ample data bearing on this subject will soon become available from the numerous new-planting experiments which have been established throughout the country during the past three years under the provisions of the restriction scheme. These experiments are comprehensive and critically designed, and will provide an opportunity for studying the behaviour of the root parasites under all practicable methods of opening and subsequent cultivation.

Control in Replanted Areas

As in the previous year the main subject of experimental study was the problem of root disease control in preparation for replanting. In this connection the two large-scale field experiments established in 1937 were continued, and towards the end of the

TABLE I

Root-Disease Replanting Experiment B.K. 1. (planted 1937)

Results to end of 1938

Treatments	Nos. of cases found during 1st round of inspection (Sept.—Nov.)										Costs (in dollars per acre)		
	(a) Rubber Trees (partially infected and dead)			(b) Bush Cover Plants (dead bushes only)			(a) + (b)						
	Fomes lignosus (1)	*G.pseudo ferreum* (2)	*Fomes noxius* (3)	*Fomes lignosus* (4)	*G.pseudo ferreum* (5)	*Fomes noxius* (6)	*Fomes lignosus* (7)	*G.pseudo ferreum* (8)	*Fomes noxius* (9)	Totals (10)	During 1st year after planting (11)	Prior to planting (12)	Total to end of 1st year after planting (13)
A	8	1	1	2	9	5	10	10	6	26	1.51	75.35	76.86
B	13	5	1	1	32	18	14	37	19	70	4.30	43.42	47.72
C	17	1	1	0	11	20	17	12	21	50	2.65	54.76	57.41
D	31	0	1	4	9	16	35	9	17	61	3.91	48.21	52.12
E	23	0	2	3	10	13	26	10	15	51	3.17	26.89	30.06
F	12	2	2	3	42	14	15	44	16	75	9.87	10.31	20.18
Totals	104	9	8	13	113	86	117	122	94				
	121			212			Grand Total			333			

For details of treatments see Annual Report for 1937 p. 131.

year received their first rounds of tree-to-tree inspection and treatment. The results to date are analysed below.

Inland Replanting Experiment (*Ref. B.K. 1*)

The data for this experiment are summarized in Table I. They agree well with expectations, and show several interesting features to which attention may be briefly drawn.

In the first place they provide a striking demonstration of the fact, which has gradually become apparent in recent years, that root disease control in connection with replanting is not a single problem, but a combination of two separate and unrelated problems which require separate consideration when planning a policy of control, viz:—

(a) control of root disease in areas infected by root parasites in the original stand, and

(b) control in areas outside the old root disease patches, *i.e* in areas carrying healthy trees at the time of felling.

The site chosen for the experiment was well adapted to effect a separation and to permit separate study of these two problems, since the parasite mainly responsible for damage in the original stand was *Ganoderma pseudoferreum*, whereas the parasite causing trouble where healthy roots are left to rot in the soil is invariably *Fomes lignosus* (see Annual Report for 1936 p. 83). It was expected, therefore, that the rates of incidence of *Ganoderma pseudoferreum* under the various treatments would provide a measure of the relative efficiencies of the treatments in dealing with problem (a) and would vary inversely with the amounts of digging carried out *within* the boundaries of the root-disease patches, whereas the rates of incidence of *Fomes lignosus* would provide a similar but independent measure of the efficiencies of the treatments in dealing with problem (b) and would vary inversely with the amounts of digging carried out *outside* the boundaries of the root-disease patches. Reference to columns 7 and 8 of Table I will show how closely this expectation has been realized. The only inconsistency is the low incidence of *Fomes lignosus* in treatment F, and here an additional factor had been introduced, *viz.* the poisoning of the stumps of the trees after felling by injection with sodium arsenite.

The effect of stump-poisoning in lowering the incidence of *Fomes lignosus* in the F plots is a matter of considerable practical interest. The method has often been suggested by non-technical observers as a means of controlling root disease at the time of replanting, but has usually been regarded by its advocates as a method of destroying roots already infected by root parasites, *i.e.* as a method of dealing with problem (a). It is, of course, useless for this purpose, a fact which is confirmed in the present experi-

ment by the high incidence of *Ganoderma pseudoferreum* in treatment F. The present results show, however, that as a method of dealing with problem (b) the method merits serious consideration. More green timber was left to rot in the soil in treatment F than in any other treatment included in the experiment, yet the incidence of *Fomes lignosus* under this treatment was only half the incidence under treatments D and E in which the chances of infection and spread were greatly reduced by the removal of the stumps and laterals of the healthy trees, and no higher than in treatments B and C in which all healthy roots were extracted to a depth of 9 inches. It is too early yet to say how stump-poisoning compares from the economic point of view with the simple method of stump extraction at present recommended for use in healthy areas. The method, however, is distinctly promising, and well worth a trial on any estate interested in large-scale replanting.

The success of the method depends on the fact that poisoning hastens the onset of decay, and therefore shortens the period between felling and invasion by saprophytic organisms during which the roots are green and abnormally susceptible to attack by *Fomes lignosus*. It is during this period that the sources of infection are developed which later give rise to losses in the replanted stand. Shortening the period of susceptibility reduces both the number and size of these sources, and thus provides a useful measure of control. It is still difficult to explain satisfactorily where the *Fomes lignosus* comes from. Some undoubtedly originates from dormant sources which existed in the original stand. Spore infection of the partially exposed and highly susceptible green root-fragments cannot, however, be entirely disregarded.

The data also illustrate in an interesting way the characteristics of rhizomorph production of the three main root parasites. *Fomes lignosus* has a mobile and diffuse rhizomorph system which spreads far in advance of rotten tissue, the ratio of dead to total infected plants at any given instant being invariably low; *Ganoderma pseudoferreum* and *Fomes noxius*, on the other hand, have compact systems which rarely advance more than a foot or two ahead of diseased tissue, the ratio of dead to total infected plants being high and approaching unity. These differences are well brought out in the data under reference, the figures for rubber trees being 43 : 104, 8 : 9 and 6 : 8 respectively (only the figures for total infected trees are given in Table I). Among the bush covers the differences were even more clearly marked, although here the total numbers of infections could only be estimated (collar inspection being impracticable). The numbers of sites carrying dead plants were 13, 113 and 86 respectively, but whereas in the case of *Fomes lignosus* general observation showed that the total number of in-

fected sites was greatly in excess of the number of sites carrying dead bushes (the ratio being at least 10 : 1), in the case of both *Ganoderma pseudoferreum* and *Fomes noxius* very little mycelium was seen except in the neighbourhood of dead or moribund plants.

With reference to the *Fomes noxius* infections, a large proportion of these (nearly 60 per cent) were directly traceable to contact with diseased rubber logs lying on the surface of the soil; these logs had undoubtedly become infected after felling, most probably by the action of wind-blown spores (*c.f.* Annual Report for 1937, p. 134).

With regard to costs, the main point to observe is that, broadly speaking, the cost of treatment during the first year after planting varied inversely with the cost of treatment prior to planting. This again was in accordance with expectations (see Annual Report for 1937, p. 130). Statistical analysis showed that costs for treatment F were significantly greater than costs for treatments B, C, D and E, all of which were greater than those for treatment A. Significant differences between B, C, D and E could not be demonstrated. Owing to a misunderstanding costs for areas under bush and creeping covers were not recorded separately. It is known, however, that the former were at least three times as high as the latter (this will readily be understood by reference to Table I).

Coastal Replanting Experiment (*Ref. H. 1*)

The data obtained in this experiment are summarized in Table II. Owing to the smallness of the area and the absence of bush covers the incidence figures are as yet too low to justify detailed comment. Statistical analysis suggests, however, that the incidence under treatment C was higher during the first year than the incidence under A or B, and that D may have had the least infection though its difference from A and B is not significant.

With regard to costs it should be explained that the high figure of $10.12 per acre given in the Table as the cost of treatment C during the first year after planting includes the sum of $7.51 per acre spent in widening the dug-over strips along the planting rows from 5 to 10 feet. The cost of digging the original strip was $17.31 per acre. The delay of a year in digging the second instalment resulted, therefore, in a saving of nearly 60 per cent of the digging costs. The treatment was designed to effect an economy in this direction, but it was not anticipated that the amount saved would be so considerable.

It will not be possible to separate problems (a) and (b) in this experiment, since *Fomes lignosus* (as is common in coastal districts) was the only parasite active in the original stand. The

old root-disease patches, however, were not extensive, and the experiment may therefore be regarded primarily as an investigation of problem (b) (this is the more important problem on flat coastal soils).

TABLE II

Root-Disease Replanting Experiment H. 2. (planted 1937)
Results to end of 1938

Treatment	Nos. of cases during 1st year after planting	Costs (dollars per acre)		
		During 1st year after planting	Prior to planting	Total to end of 1st year
A	33	1.10	73.69	74.79
B	31	1.44	37.19	38.63
C	58	10.12	17.31	27.43
D	16	1.58	11.43	13.01

For details of treatments see Annual Report for 1937, p. 133

In addition to the two experiments dealt with above, three further experiments were commenced during the year, details of which are as follows:—

Experiment B.K. 2 (*Inland District*)

This is a small supplement to B.K. 1, and is designed to compare treatment F in the latter experiment (*i.e.* stump-poisoning with sodium arsenite) against a control in which the stumps are left untreated. Three ground-cover treatments (bushes, creepers and no cover) are superimposed upon the clearing treatments. There are three replications of the clearing treatments and six of the cover treatments, the total area being six acres and the unit plot one-third of an acre.

Experiment L.P. 1 (*Coastal District*)

This experiment is rather similar in design to H. 1, but is laid down in a different part of the country. The original stand had been felled, the tap roots and larger laterals removed and known root-disease patches dug over, before the area became available for experimental work. Additional treatments were then carried out as follows:—

A. Uniform digging and root removal to a depth of 18 inches.

B. As A, but digging only to 9 inches.
C. No further treatment.
D. Digging strips 10 feet wide and 18 inches deep along the planting rows; the remainder of the area being left undug.
E. As D, but digging only to a depth of 9 inches.

The treatments were replicated five times in Latin Square arrangement, the total area of the clearing being 10 acres.

EXPERIMENT H. 2 (*Coastal District*)

This experiment (which is situated in the same locality as H. 1) is designed to investigate additional methods of dealing with problem (b).

This problem can be attacked in two different ways, *viz.* (1) by the complete or partial extraction of the roots of the healthy trees prior to planting (a full range of methods of this type is included in the experiments described above), and (2) by treating the root systems of the healthy trees prior to, or at the time of, felling, in order to render them immune or resistant to subsequent attack by root parasites.

Poisoning the root systems by injection with a strong plant killer such as sodium arsenite is a method of the latter type which has already shown promise in Experiment B. K. 1. Another possible method is one suggested by the work of Leach* who found, while investigating the control of *Armillaria mellea* in tea plantations in East Africa, that the root systems of certain forest trees which had been ring-barked prior to felling were less susceptible to attack by this parasite after felling than the root systems of similar trees which had not been ring-barked. This lowering of susceptibility he attributed to the fact that the roots of the ring-barked trees were practically devoid of starch at the time of felling, and for that reason were more susceptible to invasion by saprophytic organisms than by parasites of the *Armillaria* type. If a similar argument could be shown to hold with regard to the rubber tree and the root parasite *Fomes lignosus*, ring-barking would provide a simple and convenient method of dealing with problem (b) which would be very acceptable to the industry, particularly in flat coastal districts where this problem often causes serious trouble.

The experiment under reference is planned to compare the ring-barking method, together with two variations of the poisoning method (*viz.* stump-injection after felling, and injection into the living trees prior to felling), against a control in which the stumps

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have been left untreated. The ring-barking and tree-poisoning treatments were carried out early in June, from four to six months in advance of the proposed felling date, and stump-poisoning just prior to planting. Three ground-cover treatments (bushes, creepers and no cover) were superimposed on the root treatments in factorial arrangement, the twelve possible combinations being replicated three times in randomized blocks. The total area of the clearing is 36 acres, each plot being one acre in extent. Planting was completed by the end of the year.

Comparative estimates of the starch contents in the roots of the trees under the various treatments were made at the end of September, and again early in December, and gave interesting results.

Root sections from the treated trees were cut longitudinally and the exposed surfaces planed, stained with iodine-potassium-iodide solution and compared with similarly treated sections from standing trees. Comparisons were first made macroscopically, and were then confirmed by microscopic examination of the outer tissues of the wood cylinder near the cambium. On this basis it was found that:—

(1) In trees ring-barked 4½ months before felling the roots had lost 52 per cent of their starch content at 3½-4 months, and 86 per cent at 6 months after treatment.
(2) In trees frill-girdled and poisoned with sodium arsenite 4 months before felling the roots had lost 98 per cent of starch at 5½ months after treatment.
(3) In stumps poisoned by injection with sodium arsenite immediately after felling the loss was 65 per cent at 2 months after treatment.
(4) In untreated stumps the loss was only 4 per cent during the first 2½ months after felling.

It should be emphasized that the percentage figures given above were arrived at by a system of visual grading, and not by precise measurement. They are, however, reasonably accurate. The method used will be described in detail elsewhere.

There appeared to be a fairly close relationship between the rate of loss of starch and the rate of invasion by saprophytic fungi. It will be necessary to wait until the root disease attack commences, however, to determine whether more rapid invasion by saprophytes has resulted in a reduction in the spread of *Fomes lignosus*.

Diseases of the Tapping Panel (Mr. Beeley)

Mouldy Rot (*Ceratostomella fimbriata*)

An exceptionally dry period was experienced throughout the lowlands of Malaya during the middle of the year and it is

interesting to record the occurrence of Mouldy Rot on the tapping panel of rubber trees on an estate in South Perak in July. The rainfall for the two months previous to the occurrence was 9.1 inches falling on 10 wet days. It was found that the fungus was present in a rare form consisting mostly of fimbriated perithecia tipped with a mucous spore mass and of a flat felt of dark green mycelium in which were embedded numerous thick-walled macroconidia. The dense, white felt of endoconidia normally present was absent in this case; though a thin white felt of *Fusarium* sp. was present in some of the bark chippings, which may have developed in transit.

For the past four years, except for a single case recorded in 1936, the perithecial stage has not been recorded on rubber bark in the field and even in culture it has proved difficult to obtain. Cultures of the fungus from the Perak estate have shown vigorous growth of the perithecial stage, though all the other stages are present and thus confirmed the identity of the species.

Tests of Fungicides in Control of Mouldy Rot

A number of proprietary fungicides were subjected to field tests during the wet season November-December in an area of old rubber heavily attacked by Mouldy Rot. They were representative of three types of fungicide, those in paste form used neat, the white fluids requiring dilution with water and fungicidal oils requiring dilution with a cheap inert oil such as palm oil. None, however, proved suitable for control of Mouldy Rot and consequently there has been no addition to the Government White List of fungicides to be used for that purpose.

Further experiments were completed during the year on the influence of palm-oil-Izal-oil mixtures on Mouldy Rot and bark renewal mentioned on p. 154 of the Annual Report for 1937, and, though the rate of bark renewal was satisfactorily speeded up certain disadvantages of the palm oil treatment of the tapped panel were brought out, such as slipperiness of the tapping surface, tendency to over-softening of the bark with resultant wounding by the tapping knife and also decomposition of the palm oil which, with the sun's heat, causes an over-penetration of the new bark surfaces resulting in death of at least one millimetre thickness of bark. In some experiments layers up to three millimetres thick were observed to have been killed by successive applications of the oil, so that in later experiments care was taken to minimise the overlapping of successive weekly applications of the palm oil mixtures to the bark freshly exposed in tapping. This disadvantage was not observed in experiments carried out with emulsified linseed oil in 1934-35 and it is possible

that better results may be obtained by the use of the more expensive linseed oil which also promotes improvement in bark renewal following its application to the freshly-tapped bark of rubber trees.

A report was prepared on the year's work done with the palm oil mixtures, in which the experiments consisted of six different treatments replicated on four estates in different soil and weather localities. The report indicates the following conclusions:

1. The application of controlled quantities of palm oil to the freshly-tapped bark of old, hard-barked rubber trees improve the subsequent renewal of bark to a very significant degree.

2. The inclusion of the fungicidal oils A, B and C in the palm oil afforded no added advantage unless panel disease was present.

3. Fungicidal oil at 5 to 10 per cent. in palm oil would be a suitable mixture for treatment of Mouldy Rot disease of rubber trees acting both as a fungicide and as promoter of bark renewal.

4. The application of excessive quantities of palm oil to the panel may have certain disadvantages which, however, can be overcome to a considerable extent in ordinary rubber estate practice.

In view of the fact that work on substances promoting bark renewal is being carried out by the Botanical Division further work on the use of vegetable oils such as linseed oil either alone or as carriers for growth-promoting substances will be carried out entirely by that Division.

Black Stripe and Patch Canker (*Phytophthora* sp)

Owing to the abnormally dry weather experienced during the year under review very few cases of Black Stripe canker of the tapping panel or Patch Canker of the trunk of the tree have been recorded and the situation in regard to these diseases is little changed from that recorded last year.

Sunscorch of the Tapping Panel

As reported last year, sunscorch of the freshly-tapped bark has again been in evidence, as might be expected in such a dry year and though a single treatment weekly with any of the fungicides normally used for Mouldy Rot will prevent any permanent damage being done it is of interest to note the success obtained with the palm oil and palm oil-fungicide mixtures on poor hard-barked rubber trees mentioned above. It should be possible to

prepare a fungicide-oil mixture of such a nature as to preserve the freshly-tapped bark from fungus or insect attack, to prevent excessive heating of the bark and loss of moisture and at the same time allow the ingress of air so necessary to the growth processes within the rapidly regenerating cortical tissue. It should be noted that the application of otherwise harmless greasy mixtures or tars to large surface areas even of mature bark will cause suffocation and death of the cortex beneath, so that considerable care must be exercised both in composing such a mixture and in its application to the freshly-exposed cortex of the tapping panels.

Brown Bast

Several reports of Brown Bast occurring in areas of budded rubber have been reported during the year. The seriousness of the situation lies in the fact that the early stages of the disease usually occur during the drier periods between the two moist, growth-flush periods. The tapping cut dries up for no apparent reason though occasionally longitudinal splits just below the cut may be evident. On the advent of a growth-flush, however, gum deposition and meristematic activity is set up within the cortex which rapidly results in the more obvious symptoms appearing on the tapping panels. At this late stage prevention is practically impossible and necessitates recourse to drastic surgical treatments of affected panels. In the cases investigated it was found that if due attention had been paid to the change in the dry-rubber-content of the latex throughout the period of tapping it would have been possible to prevent a serious outbreak of this physiological disease merely by shortening the length of cut or increasing the interval between tappings. On many estates the volume and the dry-rubber-content of the latex brought in by each tapper are recorded daily and afford a reliable means of detecting changes in the composition of the latex and the onset of Brown Bast.

It has been found that some clones growing on poor light soils may show no signs of Brown Bast under normal a.d. tapping but on good high-yielding soils the same clones under the same tapping system may show a fair proportion of Brown Bast. Also, while a ½ a.d. system is satisfactory during the first two or three years of tapping some clones require a less severe system in later years if Brown Bast is to be avoided. Some clones have a tendency to dry up as the cut approaches the union. This indicates the need for a change-over to a new panel.

Although in most mature rubber areas up to three or even five per cent of dry or Brown Bast trees may normally be found it is not necessarily an indication of over-tapping. If, however,

the d.r.c. is watched and the percentage of dry trees increases simultaneously with a lowering d.r.c. consideration should at once be given to measures for reducing the severity of tapping. It seems preferable deliberately to accept a 10 to 15 per cent less yield than to have the yield fall off the same amount owing to disease.

Stem and Branch Diseases (Mr. Beeley)

Pink Disease

The situation is little changed from that reported for the previous year. No noticeable increase in Pink Disease in young rubber areas carrying a cover of *Desmodium ovalifolium* attacked by the same disease has taken place, and several areas of the cover after death from Pink Disease have subsequently been replanted with other species of cover.

Diseases of Clones

Records of diseases of clonal rubber met with in advisory work and in experimental areas have been kept up to date during the year. There appear to be no outstanding points of note, and no special susceptibilities of any clone to certain diseases have yet become evident. The foliage and shoot dieback mentioned in last year's report appears to be due to nutritional defects as previously stated and suitable manuring with potash and phosphates tends slowly to rectify the conditions, an improvement which would no doubt be more rapid under more moist soil conditions than have obtained during the past two years.

Leaf Diseases (Mr. Beeley)

Hevea Leaf Mildew (*Oidium Heveae* Steinm)

As in previous years the whole of the rubber-growing country west of the main range was inspected during the refoliation period and a report on the incidence of leaf mildew was written, a summary of which reads as follows :—

> "The pronounced dry weather brought on by the N.E. "monsoon caused an intense wintering of rubber trees "generally throughout the Peninsula. This drought was "unfortunately interrupted in the north by some twelve days' "heavy rain in January which delayed the wintering by two "or three weeks, so that at the beginning of March refoliation "was only just beginning instead of being nearly complete "as in previous years. Further south, however, weather "conditions had remained more favourable and a large per-

"centage of the rubber trees had obtained a good healthy "canopy of new foliage before the break in the drought about "the 6th or 7th of March. Thus, in contrast to previous years, "the central and southern districts have had a good wintering "followed by production of an excellent new foliage compar- "atively free of disease, while the northern districts have had "a later wintering than usual and consequently a large pro- "portion of the later refoliating trees were caught by the dull "weather of late March and April and suffered attack and "considerable leaf fall by the mildew fungus.

"The number of reports, 129, is considerably less than in "previous years in spite of the usual warning circulated to "managers and publication of last year's Oidium report early "in the year. It is noticeable that whereas the numbers of "reports from the southern States Johore, Malacca and Negri "Sembilan show considerable decreases those from Selangor, "Perak and Kedah show progressive increases over the same "records for 1937."

The accompanying table shows the rainfall for the first five months of the year; the position of the dry and wet periods for each district can be noted.

TABLE III

Rainfall in inches

District	Janu-ary	Febru-ary	March	April	May	Total for five months
Kuala Lumpur (Sel.)	5.39	6.06	8.87	6.20	5.32	31.84
Sitiawan (Pk.)	6.79	4.65	5.18	4.76	7.62	29.00
Port Dickson (N.S.)	2.35	1.47	8.56	4.17	3.14	19.69
Tampin (N.S.)	3.18	1.68	10.07	7.07	11.99	33.99
Malacca (S.S.)	3.85	0.67	10.00	7.44	3.39	25.35
Kluang (J.)	4.31	5.02	10.76	7.66	14.90	42.65

As last year, the various sulphur-dusting programmes were curtailed or abandoned as it was considered that the foliage of most of the trees had reached the stage at which they appeared to be immune from attack by mildew.

In view of the rapidity with which the disease can spread from infinitely small beginnings, and in view of its usefulness for control of other diseases and pests, the writer again advises estates

to provide themselves with a motor or knapsack duster for use in areas of valuable planting material.

The lighting rapidity of this year's outbreak of leaf mildew, including areas in Kedah not previously badly attacked, points towards the theory that the fungus hibernates in the green buds of the terminal shoots of the rubber trees. There is no gradual spread of infection from a focal point of a field of rubber, but the disease appears suddenly and simultaneously on any and every tree in that area whose leaves are in the immature stage. Further examination and culture of infected green shoots and leaves in the cold incubator has failed to reveal a resting spore or resting mycelium.

Minor Leaf Diseases

There is little of special note to record under this heading, the main trouble in young rubber foliage being caused by the combination of mites, spiders and various leaf spot fungi such as *Helminthosporium Heveae* and *Scolecotrichum Heveae,* and rim blight fungi *Gloeosporium* sp., *Colctotrichum* sp., *Phyllosticta* and *Ascochyta* sp., many of which may be found on the same whorl of young leaves at the same time.

In this connection, however, an experiment was carried out in a closely-planted nursery of rubber seedlings to discover possible methods of control of leaf spot, spider and mite damage by the use of various insecticidal and fungicidal dusts and sprays.

The area of the nursery was about one-and-a-half acres and was planted in rows 2 feet apart with seedlings varying from 3 to 6 ft. in height. The area was divided into nine strips with two rows of seedlings left untreated between neighbouring numbered strips. The nine different treatments were as follows:—

1. Lunevale colloidal sulphur dust 10 lb. per acre at weekly intervals.
2. Cirrus sulphur dust 10 lb. per acre at weekly intervals.
3. Copper sulphate 1.0 per cent in water as a spray at weekly intervals.
4. Pyrethrum powder (30%) sulphur (70%) 5 lb. per acre at weekly intervals.
5. Bordeaux mixture, as a spray at weekly intervals.
6. Derris powder (30%) sulphur (70%) dust 5 lb. per acre at weekly intervals.
7. Pysect (Pyrethrum extract) as a spray at weekly intervals 3 oz. per gallon of water.
8. Control, untreated plot.
9. Cuprous oxide powder as a spray fluid, 1.0 oz. per gallon or 0.3% Cu.

Treatments were applied in September and first half of October, a time when a new whorl of leaves is normally produced by young rubber plants. Normally a rather wet season sets in at this time but in 1938 rain was infrequent and light, giving ideal conditions for the test and for the incidence of leaf fungi and mites. The whole nursery was suffering badly from leafspot fungi, mites and spiders and many of the seedlings were dwarfed on this account.

The plots were inspected at the end of October and again at the end of November as well as during the actual spraying period.

It was concluded that in this test the copper and pyrethrum sprays have proved the more effective in control of leaf diseases and pests of rubber seedlings. The seedlings were small and spraying was easily and efficiently carried out. Of the dusts those containing 33 per cent insecticide powder were slightly more efficacious than normal sulphur dusts. It is doubtful if the amount of control obtained even by the copper sprays is of economic value.

It is possible that had the seedlings been higher, say over 10 feet, the more mechanical factors would have influenced the results such that the dusts may have proved more efficacious than spray fluids, as has been previously found by the writer and other workers.

Cockchafer Pest (Mr. Napper)

The steady increase in the incidence and importance of this pest, which had become noticeable in previous years, was fully maintained during the period under review. Between the beginning of June, when the damage caused by the new generation of grubs began to be visible in infested areas, and the end of the year, 13 new infestations were reported from various parts of the country, 11 of which were from districts not previously known to be infested. In addition, considerable spread was reported from most of the areas infested in 1937. As a result of a questionnaire circulated to infested estates during December, it was found that the area known to be infested throughout the country at that time was some 3,000—3,500 acres, as compared with 1,500—2,000 acres at the end of 1937 and 1,000—1,500 acres at the end of 1936.

Psilopholis vestita Sharp (formerly known as *Psilopholis grandis* Cast., see note at the end of this section) continued to be the most wide-spread and dangerous species, but at least half-a-dozen other species were reported from time to time as causing damage of commercial importance. Of the new infestations referred to above three were caused by species other than *P. vestita*.

There is no longer any reason to doubt the significance of the recent upward trend of infestation. Increased vigilance on the part of estate staffs may account for many of the "new" records of less important and less obvious species, but the damage caused by *P. vestita* is too conspicuous to be overlooked for more than one or two seasons at the most on any well-run plantation, and the steady rise in the numbers of outbreaks in recent years points unmistakably to a real and general increase in the incidence of the pest throughout the country.

There is no evidence to suggest, however, that the pest is being spread bodily from one part of the country to another, either by natural or artificial means. On the contrary *P. vestita* and the other species involved appear to be already widely distributed, their increasing tendency to develop in epidemic form being due most probably to some recent change in the conditions of cultivation on rubber estates which has disturbed the former equilibrium between the pest and its environment. In this connection it is tempting to point to the increasing use of ground covers as the most probable predisposing cause. It should be remembered, however, that the first recorded case of infestation by *P. vestita* occurred in a clean-weeded area. It is probable, therefore, that other factors also are involved.

With regard to control, further experiments on soil fumigation with carbon bisulphide confirmed the results obtained in 1937, and showed that at current prices for material and labour a 90-95 per cent kill of grubs can be obtained at a cost of $50 to $60 per acre. A dose of 5 grams of carbon bisulphide at 15 ins. by 15 ins. intervals was found to be a suitable rate of application for practical purposes. It is not suggested that treatment of this nature will eliminate the pest, or remove the fundamental cause of infestation. If carefully carried out, however, it should suppress the activity of the pest for several years, and if repeated when necessary should prevent that gradual enlargement of the infested area which is such a constant and disturbing feature of uncontrolled outbreaks.

It is hoped that a closer study of the problem will eventually produce a more fundamental and less expensive method of control. In the meantime control by soil injection is the only practicable method available, and as such has been recommended to the industry for use in the smaller infested areas. A detailed pamphlet on the subject was prepared early in September and circulated to interested estates.

The problem of control in widely infested areas, where the pest has developed uncontrolled for many years, is a much more difficult matter. The damage caused by the pest in such areas, though real, is by no means spectacular, and an expenditure on

treatment of $50 to $60 per acre is not likely to be recovered in future benefits unless it can be spread over a block of rubber some 50-100 times the size of the area treated. In other words, it is unlikely to be economic for an estate to treat an area greater than 1-2 per cent of its planted acreage.

Towards the end of the year the soil-injection method was tried out on a commercial scale by an estate in North Perak. The work was organised along the lines recommended in the pamphlet referred to above but, as the supply of carbon bisulphide available was insufficient to treat the whole area, it was necessary to substitute a 2:1 mixture of carbon bisulphide and carbon tetrachloride. The rate of application was 5 grams of the mixture per injection at 15 ins. by 15 ins. intervals.

The area was nearly 40 acres in extent, remote from public roads and the railway, and at least 50 miles from any other known infested area. It provided, therefore, an admirable site for a practical test of the efficiency and economic value of the method. The immediate results were very gratifying. The kill of grubs was above the 90 per cent level, while the costs were actually below those estimated in the pamphlet. The final cost worked out at approximately $55 per acre, excluding the cost of the machines. The machines cost at the rate of $5 per acre, but it must be remembered that they can be used again if necessary.

The effect of fumigation on the rubber trees themselves was more severe than had been anticipated (judging from earlier small-scale experiments). Partial defoliation occurred within a week or ten days after application, and many of the smaller roots were destroyed. Recovery set in quickly, however, and the stand is unlikely to suffer permanent harm. Similar defoliation and root damage were observed on another estate where extensive treatment was tested over an area of two to three acres, using the same mixture and rate of application. In this instance the trees were only two years old, and damage became visible 48 hours after application. One or two poorly grown trees were lost, but the remainder quickly recovered, and were putting out new foliage within ten days after treatment.

(*N.B.* It has recently been shown by an authority at the British Museum (see *Journal of the F.M.S. Museums,* Vol. XVII, part 2, Dec. 1938, p. 267) that the species hitherto referred to as *Psilopholis grandis* Cast. is actually *P. vestita* Sharp. He says:—"The two species are extremely alike, but *P. vestita* is slightly larger and has the abdomen very smooth and shining in the middle, with only a few scattered hairs, whereas *P. grandis* is closely and uniformly hairy beneath." Judged by the latter criterion the local pest is certainly *P. vestita,* and this name will therefore be adopted in the future).

Termite Pest (Mr. Napper)

Increased pressure of experimental and advisory work in connection with the cockchafer pest greatly curtailed the time available for investigations under this heading. Comparative tests of the trail-injection and standard methods of control were continued, however, at the Experiment Station, the results obtained confirming the conclusions reached in the previous year (see Annual Report for 1937 p. 144).

There is now no doubt that trail-injection with arsenical dusts is a very effective method of control. Unfortunately it is not yet possible to recommend the method unreservedly on account of the danger of bark burning, particularly during the wetter months of the year. No trouble of this kind has yet been experienced at the Experiment Station where plain white arsenic has been used, though one of the commercial preparations caused a certain amount of damage during the rains of October and November, and had to be rejected. On estates, however, burning has occasionally been reported even with plain white arsenic.

Bark burning is possibly due to the presence of more soluble and therefore more caustic compounds of arsenic, in addition to arsenious oxide, in the prepared arsenical dusts and samples of white arsenic at present available on the local market. There is reason to believe that pure white arsenic could be used without danger of burning, and it is hoped that samples of finer quality will shortly be available for test.

A perchloride of mercury treatment was introduced into the tests early in the year, the material being applied as a solution in water by a method of the trail-injection type. The method used is a very simple one. The earth casings on the trunks of infected trees are lightly broken at the upper extremities, and 1-2 pints of a ½-1 per cent solution poured gently into the trails. Results to date show that the method is equally as efficient as the white arsenic method from the point of view of control, though it is slightly more expensive on account of the higher cost of the material. The additional cost, however, is not great, and the method is to be preferred to the white arsenic method as long as the danger of bark burning with the latter method persists.

Other Insect and Animal Pests (Mr. Beeley)

Thrips, Spiders and Mites

There is little to report regarding the occurrence of these pests, which appear to be found chiefly in inland flat and coastal areas in all age classes of rubber, though only in young rubber can a slight interference in plant growth be observed to which

the account of dusting and spraying experiments mentioned above makes reference. The annual appearance of Hevea Thrips on the Experiment Station was again recorded and several rounds of sulphur dusting were necessary in order to keep the pest in check during the refoliation period.

Caterpillars

Damage to young rubber plants by caterpillars has frequently been reported during the year, while cover plants of both cultivated and indigenous types have been completely defoliated by them, and as food becomes scarce the young bark is also removed from the stems and consumed. In older areas it is not uncommon for hordes of caterpillars, after having stripped the cover, to attack the young renewing bark of the tapping panel. The photographs on the next pages illustrate the kind of damage which caterpillars are capable of doing in a field of young rubber trees. The species of caterpillar concerned in this instance was the Noctuid *Tiracola plagiata* Wlk., but a number of other species, such as *Prodenia* sp., *Ophiuse* (*Achaea*) sp., *Mocis* sp. and *Plusia* sp. have been observed to cause similar damage. Extensive and continuous spraying with an emulsion of kerosene and lead arsenate is necessary to keep these pests in check and to preserve the young rubber trees. It has often been found that the 0.5 per cent. lead arsenate in the emulsion is insufficient to check the pest and since higher concentrations cause damage to the young rubber it has been necessary to spray the cover plants only with higher concentrations of lead arsenate and to apply a 4 per cent. kerosene emulsion without lead arsenate to the rubber plants as a deterrent.

Bugs and Beetles

Various species of bugs, white flies, and beetles have been reported causing damage to rubber, natural covers and to leguminous covers. The various species concerned and the plants on which found are given below in the list of insects identified during the year.

Coccid Pests

Scale insects and mealy bugs have again been reported damaging both the rubber trees and the cover plants. *Lecanium* sp., *Ferrisia* sp. and *Phenacoccus* sp. are of most frequent occurrence, at times necessitating drastic measures for their control. The new coccid pest reported last year from the Malacca district has been identified as *Lepidosaphes cocculi* Green. A large clearing of three-years-old clone rubber was originally affected and growth considerably retarded by the presence of the scales on the main stem

and branches as well as on the leaves. Control has been obtained by the use of kerosene or solar oil emulsion. Other areas have been examined for this pest but no further outbreaks were found.

A species of *Chionaspis* is fairly common on rubber foliage but exists in large numbers only on the upper surface of the leaves and does not cause defoliation. The species *Pinnaspis aspidistrae* Sign was found by the Senior Government Entomologist in association with the outbreak of *Lepidosaphes* in Malacca.

Ants, Crickets and Grasshoppers

These pests at times cause considerable trouble in local instances. Tests of the bait of thallium sulphate with sugar and honey against ants in seed nurseries were unsuccessful, though the same bait is excellent for control of the common household ant which apparently cannot resist the sweet bait. Field ants appear to be vegetable feeders or are carnivorous, and control by poisoned insects or poison sprays is indicated.

Crickets and grasshoppers were reported to be present in several estates causing severe damage to rubber and cover plants. The grasshopper *Valanga nigricornis* Burm. appeared in epidemic proportions on some coastal estates but was not reported in time for adequate control measures to be adopted and it was shown that when food is scarce *Valanga* will attack the rubber trees.

Snails, Slugs and Rodents

These pests continue to thrive on rubber estates but with the discovery of the meta-bran bait the molusc pests can easily be kept in check, which is especially necessary when attempting to establish legume covers from seed or cuttings. It should be noted here that the calcium arsenate, lime, cement bricks mentioned in this section of the report last year are quite useless on limestone soils or if other sources of lime are available for the snails.

In regard to the rat pest, although the application of rat lime to the basal few inches of the seedling stem affords some protection it is dangerous to cover too much of the stem or to apply it too thickly on the bark, which appears to be suffocated and growth is seriously retarded. It is now generally recognised that the rat menace in young rubber areas with indigenous covers requires close attention and the expenditure of estate funds on wire, tin or bamboo guards for the plants may not be considered uneconomical. Towards the end of the year a circular was issued dealing with the use of poison baits, traps and plant protection measures in combatting the rat menace. In this connection the

Institute for Medical Research has very kindly tested the various proprietary and home made rat-baits and will publish a bulletin on this and other rat control work which has been carried out there.

Rhinoceros Beetle (*Oryctes rhinoceros*)

About the middle of the year an investigation was carried out in the Krian district on the danger of the breeding of Rhinoceros beetle larvae in felled rubber trees left on the ground when replanting rubber areas in districts also carrying large areas of coconut palms. The following extracts of the report on this investigation are of interest.

"It is established by this survey that while an area of felled rubber like that on X Estate replanted area is a potential breeding ground for the Rhinoceros beetle and similar beetle types, the bare rubber logs are unattractive to the egg-laying beetles. The soil and root mass at the base of the tree forms, however, a *very desirable* egg-laying and breeding place for the Rhinoceros beetles especially if such boles have a reasonable covering of verdure. No doubt such a situation affords ample protection against enemies and sun to enable egg-laying and feeding to take place. It is also found that the soil surface beneath such boles of trees contains a fair population of grubs especially at 100 yards distance from the boundary of the coconut field which may indicate that the beetles were getting tired by the time they had flown that distance. The high water-table normally existing in the coconut area would prevent the larvae from thriving in such soils."

"It is established that while the rubber area carried a population of about 1,080 grubs per acre quite a moderate estimate of the number of grubs in the original coconut area lies in the region of 80 grubs per acre. When it is considered also that the material used for bridges and fencing in small-holdings coconuts is usually coconut palm logs, which are nearly always found to be grub-infested at the points in contact with soil, a very considerable source of infestation by this beetle is constantly present. The general opinion is that the whole of the Krian District is normally heavily infested with Rhinoceros beetles from those breeding places."

Thus the felling of the rubber trees and improvement in drainage of the replanted area on X Estate may be said merely to have aggravated an already serious situation regarding Rhinoceros beetle infestation in that district."

"It is established that the bare rubber logs with or without cover crop do not make a satisfactory breeding ground for the Rhinoceros beetle. This may be due to the fact that the surface

of the timber is hard and sun-dried while the portion in contact with the ground rots quickly and is heavily infested with other beetles, termites or true ants which may be considered enemies of the Rhinoceros larvae. Control measures need not involve the destruction of the straight rubber logs which may therefore be used for soil conservation work. It is however important that the root and soil-carrying boles of the old trees be destroyed or inspected at about half-yearly intervals and all grubs and beetles collected and killed."

Diseases and Pests of Cover Plants

There is little change from the situation reported for 1937 save that with the drier seasons experienced in 1938 a larger number of pests appear to have called for attention, chief among which are the coccid bug *Phenacoccus iceryoides* on bush legumes, the coccinellid beetle *Epilachna indica* on creeping legumes and the black fly *Aphis laburni* on the large creeping legumes. The latter has been particularly troublesome in the drier districts and has caused dieback of such covers as *Pueraria* sp. and *Calopogonium* sp. over considerable acreages.

The root-knot eelworm *Heterodera marioni* continues to give considerable trouble in many estates and the need for investigation into the possibility of growing varieties of legumes immune or resistant to this pest is becoming more evident. It is hoped that experiments on these lines will be commenced during the current year.

The following is a list of the more common species of insects and other pests of rubber trees or cover plants identified during the year.

Name	Type	Plant on which found
Crossotarsus Wallacei Thom.	Caterpillar and Beetles	Hevea
Epilachna indica Mulls. ...	„ „ „	Legume covers
Terias hecabe L. ...	„	Bush legumes
Lymantriid larvae. ...	„	Hevea
Lamprosema diemenalis Guen.	Pyralid larvae	„
Thosea sinensis Wlk. ...	Noctuid Larvae	Natural covers
Tiracola plagiata Walk. ...	Caterpillars	Young Hevea and many species of covers
Prodenia litura F. ...	„	-do-
Mocis undata ...	„	-do-
Phenacoccus iceryoides Green	Coccid bugs	Bush legumes
Homoeocerus serrifer Westw.	Bug	Legume covers

Pseudococcus sp.	Mealy bug	Bush legumes
Ferrisia Virgata Ckll.	„ „	Hevea
Lawana conspersa Walk	Flattid Bug (White fly)	Legume covers
Aphis laburni Kalt	Aphid (Black fly)	„ „
Tarsonemus translucens	Mites	Bush covers and Hevea
Hypomeces squamosus F.	Beetles	Hevea seedling
Lepidosaphes sp.	Scale insect	Hevea
Tetraponera rufonigra Jerdon	Ants	„
Sticholatis 4—signata Wse.	Coccinellid Beetle	Bush legumes
Heterodera marioni	Eel-worm	Legume covers
Pinnaspis aspidistrae Sign	Scale insect	Hevea
Chionaspis sp.	„ „	„
Parmarion reticulatus Hass.	Snail	Hevea and covers
Oryctes rhinoceros L.	Beetle grub	Rubber tree boles
Vaginula sp.	Slug	Rubber and covers
Achatina fulica Fer.	Giant snail	„ „ „
Subulina octona Brug.	Small snail	Legume covers

Bacteriology (Mr. Beeley)

No further work was done during the year on the bacteriology of soils owing to pressure of culture work regarding the supply of legume nodule cultures for estate and experimental work.

Work on the NODULE BACTERIA has proceeded apace and a considerable amount of information has been obtained by numerous cross-inoculation experiments regarding the specific nature of pure cultures now in our possession and which have been obtained as far as possible from areas where the particular legume species grows well under shade and without any special manuring.

Cultures of the following of *Rhizobium* can now be supplied to estates for experimental inoculation of legume seed :

Centrosema pubescens	*Tephrosia* sp.
Pueraria javanica	*Crotalaria* sp.
Calopogonium muconoides	*Desmodium* sp.
Vigna hosei	
Derris sp.	

of which varieties from various soil types to the total of some 22 cultures in all are under constant subculture to meet the local demand for commercial cultures by estates. About 144 estates have been supplied with cultures to the total of 920 tubes. Yeast

extract manitol-agar is the medium used for these commercial cultures as it gives considerably better and more vigorous growth of Rhizobia than other media tried. Experiments to discover suitable methods for multiplication of the *Rhizobia* on the estate have shown that skim milk with 0.1 per cent of calcium diacid phosphate or other soluble phosphate added is a medium which can easily be obtained and affords a degree of multiplication of the organisms such that one tube of culture normally sufficient for 25 lb. of seed if used direct will, if extracted into one or two gallons of skim milk phosphate medium, and incubated at low temperature for 56 to 72 hours, produce sufficient culture to inoculate three or four hundred pounds of seed. This method of multiplication of culture has now been carried out successfully by many estate managers and appears to be a cheap, easy and reliable method of inoculation.

In this connection circulars have been prepared giving explicit directions for use of cultures for inoculation of seed, for multiplication of cultures and for adopting these methods for local experiments using crushed nodule cultures.

Although many estate managers have had moderate success in the use of inoculated seed for establishment of legume covers, others appear to be relying entirely on the inoculation to establish the cover and no assistance by manuring or removal of competing rubber roots from the beds or drills is given. It is here stressed that inoculation with specific active *Rhizobia* is only one of the many factors concerned in the establishment of leguminous cover plants and unless all the other factors are considered and acted upon where necessary inoculation will merely improve early growth but in a few weeks time the plants will become yellowish and gradually die.

The Soils Division is responsible for the field experiments now being carried out to determine the mineral requirement of legumes for their establishment in rubber estates and the results to date will be found in the annual report for that Division.

Latex

During the year little time has been available for intensive work on the bacterial numbers in fresh and preserved latex, but some interesting results have been obtained concerning the changes in bacterial population of latex at various hourly periods on the day of tapping up to the point of natural coagulation.

The effect of addition of ammonia to the latex at different hours of the day has also been studied and has led to some very interesting possibilities and results.

A large number of samples of latex taken alternate daily over a period of four months were examined to ascertain the hourly changes in numbers of the bacteria in fresh latex. An early sample of latex was obtained from the Institute's small-holdings close by the laboratories and counts were made at hourly intervals till about 3 p.m. at which time flocculation usually commences. The figures show that in fairly clean latex having counts of less than 7 million bacteria per c.c. at 9 a.m. the numbers remain fairly steady or may decrease slightly until 11 a.m. after which a rapid increase sets in resulting in counts of 100 to 400 or even a thousand or more millions by 3 p.m. A few samples taken of ordinary estate bulk latex received in the laboratory at 11 a.m. showed even greater numbers of bacteria.

In the preservation of latex it seemed possible that the bacterial population at the time of adding the ammonia preservative may have some bearing on the degree and period of successful preservation of the latex. Accordingly a bulk sample of fresh latex was obtained each Monday morning at 9 a.m. and at certain intervals the bulk was shaken and two samples withdrawn. To one of these samples a certain amount of ammonia was added and both samples at once plated out on dextrose agar. It was shown that the immediate effect of the addition of ammonia to the latex was to reduce the count of bacteria by 50 per cent or more, the percentage reduction in numbers being greater later in the day when initial numbers also are greater.

The rise and fall in bacterial populations of each ammoniated sample during the remainder of the week was also determined by the dilution plate method, the numbers showing peak figures on the third day after a very low count on the day following ammoniation as stated in the Annual Report for 1934.

Owing to the fact that the weather throughout the year has been fairly evenly dry no work has been possible on the seasonal differences in bacterial flora of latex.

Advisory Work

An analysis of correspondence is appended to the Report of the Director. Other details are as follows:—

Visits to Estates

Visits to Estates other than the Experiment Station	117
Visits to Experiment Station and Small-holdings ...	37
Interviews	124
Lectures	5

Specimens Examined

Leaves	144
Roots	53
Cover Plants	59
Bark	17
Stumps	11
Branches	15
Seedlings	35
Fructifications and Fungus	7
Insects	113
Fungicides and Insecticides	22
Miscellaneous	2
Latex for bacterial numbers	51
Total ...	529

Lectures

1. A lecture entitled "Diseases and Pests of Young Rubber and Cover-plants" by F. Beeley was given at the following meetings:—

   (a) The Incorporated Society of Planters, North Johore Branch, Batu Anam ... on 22.2.1938

   (b) The Malacca Planters' Association, Annual General Meeting, Malacca ... on 27.3.1938

   (c) The Incorporated Society of Planters, Teluk Anson Branch ... ... on 13.5.1938

   (d) The R.R.I. Planters' Conference, Kuala Lumpur ... ... on 29.7.1938

   (e) The Incorporated Society of Planters, Annual Conference, Penang ... ... on 24.9.1938

2. A lecture entitled "Inoculation for Establishment of Leguminous Cover Plants" by F. Beeley was given at the following meetings:—

   (a) The Incorporated Society of Planters, Nilai Branch, at Sepang Club ... ... on 19.5.1938

   (b) The Incorporated Society of Planters, Kuala Selangor Branch, Bukit Rotan ... on 25.5.1938

   (c) The R.R.I. Planters' Conference, Kuala Lumpur ... ... on 29.7.1938

3. A lecture entitled "Root Disease in Replanted Areas" by R. P. N. Napper was given at the following meetings:—

(a)	The Incorporated Society of Planters, Sitiawan Branch, Lower Perak ...	on 20.4.1938
(b)	The Incorporated Society of Planters, Kajang Branch, Kajang	on 24.8.1938
(c)	The Incorporated Society of Planters, Kuala Selangor Branch, Bukit Rotan ...	on 19.10.1938
(d)	The Incorporated Society of Planters, Ulu Selangor and Tanjong Malim Branch, Selangor	on 26.10.1938

PUBLICATIONS

1.	*Oidium Heveae* Report on the 1937 Outbreak *Journal of The R.R.I.M.*	by F. Beeley Vol. 8, No. 2
2.	The Giant Snail *Achatina Fulica* (Fer). *Journal of The R.R.I.M.*	by F. Beeley Vol. 8, No. 2
3.	Nodule Bacteria and Leguminous Cover Plants *Journal of The R.R.I.M.*	by F. Beeley Vol. 8, No. 2
4.	Diseases and Pests of New Plantings of Hevea *The Planter*	by F. Beeley Vol. 19, No. 9
5.	Root Diseases and Underground Pests in New Plantings *The Planter*	by R. P. N. Napper Vol. 19, No. 9

CIRCULARS

The following new or revised circulars were issued during the year:—

1.	Practical Hints on Sulphur-Dusting	by F. Beeley
2.	Insect and Rodent Pests of Rubber Trees	by F. Beeley
3.	Slugs and Snails—(Mollusca)	by F. Beeley
4.	Inoculation of Leguminous Cover Plants (in 3 sections)	by F. Beeley
5.	Rat Control	by F. Beeley

Tours

(a) By F. Beeley

1.	Perak, Province Wellesley, South Kedah and Penang	Wintering survey by air
2.	Negri Sembilan, Johore and Singapore	Wintering survey by air
3.	Northern States	*Oidium Heveae*
4.	Southern States	*Oidium Heveae*

(b) By R. P. N. Napper

1.	Southern States	Root Disease Control and Replanting
2.	Perak, Province Wellesley, South Kedah and N. Kedah	Root Disease Control in Replanted Area
3.	Johore and Negri Sembilan	Root Disease and Cockchafer Pest
4.	Seremban and Perak	Cockchafer Pest
5.	Tanjong Malim, Perak and Kedah	Cockchafer Pest
6.	Kedah	Root Disease eradication (mature rubber)

F. Beeley

Head of Pathological Division

Kuala Lumpur,

13th May, 1939

ANNUAL REPORT

CHEMICAL DIVISION

Staff

Numerous changes in the personnel of the Research Officers in the Division have occurred during the year. Except for a short period of a few months the full complement of officers was not available. Mr. V. H. Wentworth, appointed to take the place of Mr. A. Moore who was transferred from the Division in April 1937, arrived and assumed duty on May 6th, 1938. Dr. Edgar Rhodes, the Head of the Division, accepted an appointment to the staff of the newly-formed British Rubber Producers' Research Association in London and left the service of the Institute on September 11th. Dr. K. C. Roberts acted as Head of the Division from that date until December 17th, when he also left to take up an appointment with the same organisation. By their departure the Institute lost two officers of first-rate ability, and the Chemical Division lost in Dr. Rhodes a Head of Division and a friend who will be sadly missed by all its members. Mr. Piddlesden and the writer were available for duty throughout the year, the latter acting as Head of the Division on the departure of Dr. Roberts, pending the appointment of a permanent Head. It is expected that the vacancies caused by these departures will be filled early in 1939. Mr. Piddlesden continued the duties of an advisory officer and the major part of the Divisional advisory work has been carried out by him.

Latex Constituents and X-Ray Studies

Latex Constituents

For more than half the period under review, Dr. Roberts, in anticipation of his departure to join the staff of the British Rubber Producers' Research Association early in 1939, planned his work with a view to rounding off as completely as possible those sections of it which he will be unable to continue after leaving Malaya. This involved concentration on the study of the causes of the variability of latex and raw rubber in terms of their composition, and a corresponding decrease in activity in purely chemical investigations. His research work on latex constituents was further curtailed from September 12th to the date of his departure, during which period he acted as Head of the Division.

The findings on the causes of variability may be summarised as follows. There is a direct correlation between rainfall and the

caoutchol content of latex. Arising out of work done in collaboration with the writer, correlation appears to have been established between the caoutchol content of latex and the plasticity of the raw rubber derived therefrom. The fatty acid complex of latex also shows an appreciable variation in amount over a twelve-month period, although no cause for this variation has been established with certainty. Further work with the writer has revealed the interesting fact that the natural fatty acid content of rubber exerts only a minor effect on its plasticity. Details will be published elsewhere. The major water-soluble constituents of latex have been shown to be subject to seasonal changes (*cf.* Wiltshire, *R.R.I.M. Bulletin No. 5*). Such variations will clearly have little if any effect on the properties of plantation rubber, since these constituents are largely removed in the manufacturing processes, but they are almost certainly associated intimately with the metabolism of latex. In this connection a method has been developed for the separation of small amounts of clear filtered serum from fresh field latex. Examination of this material is highly instructive.

Other factors investigated with a view to establishing their influence, if any, on the composition of latex, have been the tapping system, the genetic strain (clonal type) of the tree, and the time it has been in tapping. Latices drawn under different standard tapping systems show only inconsiderable differences in composition. The genetic strain of the tree on the other hand is a factor of major importance, and clonal latices have been examined which consistently show either very low or very high caoutchol contents. The importance of this fact will be clear from what has been said above with respect to the correlation between caoutchol content and plasticity. Preliminary evidence has also been obtained that the composition of latex changes appreciably and progressively with respect to certain constituents as tapping is continued.

As explained above, no attempt has been made to complete any of the purely chemical investigations of latex constituents which are in hand. Work has however continued as opportunity offered on the stoichiometric reactions of caoutchene, and progress has also been made in the development of a method for the isolation of nitrogenous constituents from latex. In this connection, a survey has been made by means of the analytical method recently described in the *Journal of the Chemical Society* **215** (1938) of the distribution of latex constituents between the skim and concentrate-portions of centrifuged latex. Interesting facts have emerged which confirm Dr. Roberts' earlier published conclusions concerning the composition of ammoniated latex, and which further throw some light on the problems of the metabolic processes in

latex and of the structure of the latex globule. This work is now being prepared for publication.

X-Ray Studies

Mrs. Roberts' X-ray investigations were necessarily concluded in November. Although, of course, a very great deal remains to be done in this field, the work had reached a stage at which it may be published, and this will be done in due course. A finding of considerable general interest is that caoutchol in the unstretched condition, unlike rubber, possesses a markedly crystalline character. A preliminary announcement of this fact has appeared in a letter to *Nature* **141** (1938) 834.

Latex Preservation

Colour of Preserved Latex and Treatment of Shipment Vessels

Some work has been carried out to find an alternative filming material for latex drums which will ensure good colour in the latex without the decrease in stability caused by the latex-zinc oxide film. Towards the end of the year encouraging results had been obtained but it is not yet possible to report further details.

Putrefactive Odour in Preserved Latex

Some work on the chemico-bacteriological investigations which are being made in collaboration with Mr. Beeley has been possible, although the demands of other work in the Pathological Division have prevented much progress and there is little that can yet be reported. Some experiments were started to see if the condition of the latex and the time before addition of the ammonia had effect on the degree and period of successful preservation, and the results may have bearing on the observation mentioned in the following report on the stability of preserved latex.

Stability of Preserved Latex

The stirring-stability work on latex has been continued throughout the year using the original slow-speed stirrer and a very high-speed stirrer similar to the Hamilton Beach mixer. Towards the end of the year a new type of stirrer designed and made by our London colleagues was received and brought into action. This stirrer, which works at about 2,000 r.p.m. was fully described in a recent publication on the preparation of latex and determination of quality by Messrs. Davey and Coker of the research staff of the London Advisory Committee.

The remarks made in the previous report on the conflicting evidence which appears to exist concerning the precise meaning of stability have been further evident during the work. It has been found that the "mechanical stability" of freshly-preserved latex determined by the high-speed stirrer in the absence of zinc oxide increases with time of storage. This reverses the findings obtained with the low-speed stirrer which attempts to measure "chemical stability." However, when a small amount of zinc oxide was added to the latex during the test in the high-speed apparatus, the latex appeared to maintain its initial stability and no evidence of increase with time of storage was obtained.

Preliminary work with the high-speed stirrer has given indications that stability may be dependent upon the time which elapses between collection of the latex and its ammoniation. This is however what might be expected and further work is in progress to confirm and ascertain how important it may be.

In a series of stability-storage trials with freshly-preserved latex from different sources, it was noticed that the stability, determined by the low-speed stirrer, decreased more rapidly in the latex stored in partially-filled drums than in that stored in full ones. Further experiments are in progress to obtain more information after prolonged periods of storage.

Viscosity of Latex

Viscosity of preserved and concentrated latex

The work on the viscosity determinations by the Höppler viscometer of preserved field latex and latex concentrates has been concluded during the year. Mathematical expressions have been derived for the viscosity dry-rubber-content relationship covering a dry-rubber-content range of 0—68 per cent. It has been demonstrated that viscosity is proportional to the ratio of rubber to serum over almost the whole of the range.

Viscosity-temperature relationships in preserved latex

Evidence of possible irreversible changes in latex induced by increase of temperature has been sought in viscosity measurements, in which changes have been observed with increasing temperature, and then with subsequent decrease of temperature on the same sample. A marked hysteresis in the two curves would indicate irreversible changes. Freshly-prepared normal ammoniated latex was found to exhibit a slight but not important hysteresis in the curves, and even when the latex was held for several hours at the high temperature, the cooling curve followed so closely below the heating curve that it is evident that the heat treatment does

not change fundamentally the state of the dispersion. With centrifugal concentrate however, evidence was obtained that prolonged heating at elevated temperatures does induce a small but pronounced change in the state of the dispersion. The cooling curve now followed the heating curve but was above it, and at 15°C. the heated latex was notably more viscous. A full account of this and the above work on the D.R.C.-viscosity relationship has, at the moment of writing, just been published in the *India Rubber Journal* **97** (1939) 21 and 51.

Variation in the Composition and Properties of Latex and Subsequent Changes on Ammoniation

Latex from seedling rubber trees

In the last report it was stated that a systematic study of the day-to-day variations in the latex from a small area of old seedling rubber close to the Institute was in progress. The variations under study included the dry-rubber-content, total solids, acetone extract, acid value, "stability," surface tension, viscosity, and "creaming-ease" of the latex when fresh, immediately after ammoniation, and after ten and fifty days storage.

It has been observed that there is highly significant correlation between the D.R.C. of the fresh latex and the acetone extract, acid number, ease of creaming and the stirring-stability after ten days' storage. The correlation between D.R.C. and viscosity of the fresh latex is not so significant as it becomes after the latex has been ammoniated and stored.

The most striking information which has resulted from this work however, concerns the changes in the acetone extract and acid value which occur in the whole-latex rubber on and after ammoniation. It was found that the amount of extract and particularly its acid value increases considerably on storage, following an initial reduction after immediate ammoniation. The results have clearly shown a difference between the composition of freshly ammoniated latex and the preserved latex of commerce. It is not possible to give here a further detailed discussion of the findings but they have been published very recently in the *India Rubber Journal* **97** (1939) 82.

Latex from clone rubber trees

At the end of the year preliminary observations on clonal latex received from the Experiment Station had indicated viscosities notably higher than those shown by seedling latex of similar D.R.C. This observation is of some importance in connection with centrifugal concentration, where high viscosity in the feed

material is not advantageous. The experiments were not far advanced however, but arrangements have been made since whereby an investigation on the composition and properties of clonal latex, similar to that reported above, is now in progress. The latex is obtained from the Experiment Station and taken from the following clones:—Tj. 1, P.B. 186, B.D. 5, and Pilmoor B. 84. Arrangements have also been made whereby it will be possible for Pilmoor B. 84 latex to be obtained from some of the original buddings in tapping on Pilmoor Estate. It will thus be possible to compare the latex from old and young trees of the same clone.

Alternative Methods of Preservation

Work on the search for possible preservatives other than ammonia has been carried out as and when opportunity offered. A large number of substances both proprietary and non-proprietary have been tested in fresh latex. Among those tested the following must be considered unsuitable, either because coagulation or clotting occurred within a short time, or because the amounts required for preservation were far too great for practical purposes.

Cymag, piperidine, zinc cyanide, 1 : 5 dichlor-anthraquinone, p. cyano-benzoic acid, di-cyandiamide, cyanamide, cyclohexylamine, methyl cyclohexylamine, ethyl cyclohexylamine, amyl cyclohexylamine, morpholine, chloral hydrate, sodium salicylanilide, Santomerse D, Santomerse 3, metaldehyde, octyl alcohol, trichlor-sodium-phenate.

The encouraging results mentioned in the last report of the experiments which indicated that it appeared possible for preservation to be effected by the use of certain substances in the presence of small quantities only of ammonia, have been confirmed. Fresh latex has been kept in excellent condition when preserved with sodium pentachlorphenate in the presence of a very small amount of ammonia. This chemical was obtained by the courtesy of Messrs Monsanto Chemical Company of St. Louis, U.S.A. and is known in the trade as " Santophen 20S " or " Santobrite." A paper describing the experiments was published in the last number of the *Journal.*

At the close of the year several other chemicals were under investigation which promised to be of equal efficacy when used in the presence of a small amount of ammonia.

Concentration of Latex

Concentration by Creaming

Experiments have been carried out throughout the year to test the efficiency of available new materials as creaming agents.

Among a number of substances tested, the following have been deemed unsatisfactory on one or other of various grounds:—

Durian Seed Powder
Drumstick Gum
Grass Tree Gum
Karanai Powder (*Amorphophallus* family).

A number of proprietary products have also been tried without success. At the end of the year work was in progress in connection with some materials sent to us by our London colleagues, and they appear likely to be good creaming agents. Creamed concentrates have been prepared which are of equal and sometimes slightly higher dry-rubber-content compared with those normally obtained by the use of Tragon A (tragon seed gum); moreover efficient creaming can be carried out in the presence of lower ammonia concentrations than is desirable with Tragon A.

Reference was made in the last report to the promising results obtained with a "seed-creamer" and its use for the preparation of concentrates of unusually low ammonia content. Further work has confirmed the value of this creamer, tamarind seed powder, and a United Kingdom patent has been taken out for its use as a creaming agent. The text of this patent, which has now been registered in the Straits Settlements and the various States of Malaya, was published in the last number of the *Journal*. Trial shipments to our London colleagues were made of "Santamcream," prepared from very lightly-ammoniated latex preserved with "Santobrite" and creamed with tamarind seed powder. It was reported that the trial batch arrived in good liquid condition with excellent colour and without putrefactive odour. An account of these experiments was published in the paper on latex preservatives to which reference has been made above.

The work previously carried out on the use of substances other than vegetable or animal mucilages for creaming purposes revealed a synthetic substance of promise. A British patent has been granted for the use of "Sulphonated Lorol" as a creaming agent, and the text of this patent was also published in the last number of the *Journal*.

Concentration by Centrifuging

The small hand-driven machine which became available locally during the second half of the previous year, and was here converted to power-drive, has been used for the preparation of special samples of concentrate and skim required for the work on latex constituents. A few preliminary experiments have been carried out on the concentration of latex containing preservatives other than ammonia. The machine however is neither big enough nor

suitable for the preparation of large-scale samples, and no information has been obtained by its use, which might suggest an improvement in centrifuge efficiency by variation in design.

Arrangements have been made recently whereby it will be possible for further work on centrifugal concentration to proceed in the near future, in collaboration with the visiting engineer of a well-known firm of centrifuge makers who is now in the East to demonstrate their machines. Further the Institute has itself placed an order for another type of centrifuge of improved design which it is hoped will arrive here shortly.

Concentration by Evaporation

In order to facilitate small-scale concentration experiments with various stabilisers and preservatives, a small concentrator was designed and constructed. The apparatus does not incorporate any new principles and is somewhat similar to the original type used in the Revertex process. It was found to be of great assistance in the preparation of the special samples of concentrate and evaporated skim required by Dr. Roberts for his work on latex constituents. Experiments were carried out using "Santobrite" and ethylene-diamine to preserve the latex during concentration. In both cases coloured concentrates were obtained which were not stable without the addition of ammonia.

Concentration by Filtration

The large porous pots obtained for us by the officers of the London Advisory Committee after considerable experimentation on our behalf were tested during the year. An apparatus was designed and constructed for the continuous removal of wall deposits. The pot was fixed to a small turn-table rotating at slow speed, and had a stationary rubber-faced wiper in contact with its side and bottom. The results obtained were disappointing, and the experiments were discontinued because it was concluded that this method of "boosting" cream is of no practical utility, unless a much greater ratio of filtering surface to volume of liquid can be obtained.

Preparation of Modified Rubbers

Rubbers having the property of Low Water-Absorption

Active work on this subject was not possible until the second half of the year owing to staff shortage. An investigation was then commenced which included a comparison of the two principal methods of determining water-absorption, namely immersion of the test sample in water and suspension in air of known humidity.

The work has indicated that a reliable method has yet to be devised where differentiation is required between rubbers showing small absorption. A series of samples prepared from the same latex by different processes were not placed in the same order of absorption value when tested by the usual immersion test (20 hours at 70°C.) as when tested by suspension in air of controlled humidity, either in sheet or shredded form.

Work on enzyme treatment has been successful in reducing nitrogen contents and there now appears to be no difficulty in producing rubber which has an absorption of less than 10 mgm. per square inch when tested by immersion at 70°C. It has not yet been possible however, to produce one with a figure as low as 3 mgm. per square inch which is thought to be necessary for the rubber to command a market.

Chlorinated and Brominated Rubbers from Latex

Work has continued throughout the year on the chlorination of fresh latex by means similar to those used by our London colleagues in their work on ammoniated latex. By modification of their methods it has been possible to produce a compound which appears to be a stable product, and at the close of the year work was in progress to complete the comparison of properties of the chlorinated rubbers prepared from fresh and ammoniated latices. It has been found that much larger quantities of reagents are required for maximum chlorination of fresh latex *in situ* than are theoretically required, and it has not yet been possible to effect reductions. Some time has been given to the examination of a product obtained during the work which does not appear to have been previously described and which displays some interesting properties.

Modifications to the methods used for the estimation of the chlorine in chlorinated rubbers have been introduced and work is now in hand as a result of which it is hoped to effect further improvements.

The previous report mentioned that modifications had been made to the procedure for the preparation of brominated rubbers which, it was believed, would overcome the difficulties encountered. Unfortunately the results were not entirely satisfactory and further investigations were directed towards the chlorination work.

Preparation of Soft Commercial Rubbers

The investigations which were described in the last report on the incorporation of "peptising agents" into latex have been continued, with a view to obtaining a soft rubber as a result of the effect of the heat applied during smoking. Further supplies were

obtained of the "peptising agent" known as R.P.A. No. 2 introduced to the rubber industry by E. I. Du Pont de Nemours & Company of America. Experiments have been carried out concerning the effect of variation in the preparation treatment on the plasticity of sheet prepared from latex to which an emulsion containing the softener had been added prior to coagulation. As was anticipated the drying treatment to which the wet sheet is subjected appears to have the most noticeable effects.

It was at first hoped that by the use of this peptising agent differences in plasticity might be smoothed out. From what is mentioned later in this report however, concerning inherent plasticity differences in latices, it is unlikely that the addition of equal amounts of softening agent to latex from different sources would be found to give rubbers of the same plasticity, and experiments confirmed this. The use of a softener in different amounts might be a means of preparing rubber of uniform plasticity from clonal latex of different types.

Requests have been received and fulfilled from three sources for samples of rubber softened in the manner described, but no information is yet available concerning its suitability for the purposes for which it was sought by the manufacturers.

Towards the end of the year, by the courtesy of E. I. Du Pont de Nemours & Company, a small sample of R.P.A. No. 3 was received. This "peptising agent" has been introduced as an improvement on R.P.A. No. 2 and is a liquid. Experiments which are in hand have shewn that it is more suitable for incorporation into latex because emulsions can be prepared more readily and more cheaply.

Information on the softening caused by the incorporation of conventional "softeners" into latex prior to coagulation has also been obtained. These experiments were made in conjunction with further investigations commenced during the year, to ascertain whether other chemicals might bring about peptisation and softening of the dried rubber when added to the latex in small amounts. At the close of the year the arrival of supplies of certain chemicals was awaited in order to prepare for examination larger batches of those rubbers which the work had indicated as likely to be of interest.

Technological Studies on Rubber

General

The vulcanising and testing equipment which was installed at the end of 1937 has been in constant use throughout the year, and except for the autoclave press has given satisfactory service following an initial period during which the inevitable "teething

troubles" occurred. Unfortunately we have not yet been able to use the autoclave owing to various faults, and in consequence it has not been possible to carry out all the vulcanisation work that was intended. It is hoped that it will be available for use shortly.

The Crude Rubber Committee of the American Chemical Society (Rubber Division) proposed some time ago a special "Captax" recipe for rubber mixes used in vulcanisation testing. This recipe, which is of the accelerated type, has been adopted by the Division and is in constant use, although the older rubber sulphur mix has not been abandoned and has been used coincident with the "Captax," in order that information might be obtained concerning the agreement which may be expected when rubbers are tested in the two types of mix.

Vulcanisation Properties of Clonal Rubber

The rubber available for examination was obtained from Block 5 at the Experiment Station. This block was brought into tapping on January 1st, 1936, and consists of four plots of each of the following nine clones:—Avros 49, 50 and 152, B.D. 5, P.B. 23 and 186, Pilmoor A. 44 and B. 84, and Tj. 1. The latex is converted into smoked sheet by treatment which is so standardised that as far as possible all preparation differences have been eliminated. The rubber from the first year of tapping was destroyed by the fire at the Institute together with all relevant records.

During the year the vulcanisation properties of the clonal rubbers from the second year of commercial tapping (1937) have been examined in the A.C.S. "Captax" and rubber sulphur mixes. The figures are still under examination but the following general observations are possible:—

(a) There is agreement between the results of the tests made in the "Captax" and rubber sulphur mixes.

(b) There are changes in the vulcanising properties of the rubbers which are not caused by preparation variables and appear likely to be seasonal.

(c) There is considerable correlation among the nine clones in their reactions to these seasonal changes.

(d) In general there appears to be as much variation between the plots of the same clone as between different clones, but further statistical examination of the figures may indicate some significant differences in rate of vulcanisation between clones.

(e) There are no outstanding differences in the vulcanising properties of the clonal rubbers, and if significant differences do exist between the clones they are likely to be small.

In addition to the Block 5 rubbers it has been possible to test smoked sheet prepared in identical manner from Block 24 latex. Block 24 is a monoclone block of B.D. 5 trees growing on hilly land which is of different soil type from that in Block 5, but the trees in both blocks are of approximately the same age. The vulcanisation figures given by the rubber from the two sources indicate that the smoked sheet prepared from Block 24 latex is faster curing than that prepared from any of the four plots of B.D. 5 in Block 5. It has not been possible to determine to what extent variation exists among different plots grown under conditions similar to those of Block 24, and therefore it cannot be considered as proved that soil conditions have significant effect on the vulcanisation properties of rubber prepared from the same clonal latex. The figures obtained however are of interest because they give some evidence that the vulcanising properties of clonal rubbers are able to vary according to the soil conditions. It would not therefore appear as if the manufacture under rigidly standardised conditions of clonal sheet rubber would necessarily mean rubber of more uniform vulcanising properties. It is not yet possible to say whether or not the amount of variation between samples, prepared by similar methods from latex of the same clone grown under different soil conditions, will be less than that found in seedling rubber. Further experiments are needed to give information on this point.

From the accelerated oxygen-bomb ageing tests which have been made on the clonal rubber there is no evidence to attribute either improved or impaired ageing properties to any particular clone; but no more than a preliminary survey of their ageing properties was possible during the year.

Vulcanisation Properties and Variability of Malayan Sheet Rubber

Although a good deal of research work has been carried out on the subject of variation in the vulcanising properties of sheet rubber and its causes, it is evident that considerable variation still exists. It is also unfortunately evident that this variation can cause a good deal of trouble to the manufacturer. Whilst it is understood and agreed that factors such as climatic and soil conditions, age and breed of the tree may be expected to influence the vulcanising properties, and so give rise to variation, it appears very unlikely that the magnitude of the differences still found can

be accounted for by these causes. In connection with work on controllable variation it was considered desirable that information should be obtained concerning the degree of uniformity which now exists. During the year a large number of European-owned estates were asked to send samples of their normal sheet for vulcanisation tests. Samples were received from estates whose planted acreage accounts for approximately 22 per cent of the total Estate* planted acreage of Malaya, and were reasonably representative of various parts of the country. Vulcanisation tests in both "Captax" and rubber sulphur mixes were in progress at the close of the year. Results are not yet available but very big differences between some of the rubbers are apparent.

Statistical figures show that 39 per cent approximately of the total acreage of rubber planted in Malaya is in the form of small-holdings, and it is certain that the major portion of sheet rubber produced on these holdings is not prepared by methods similar to those in use on estates. Advantage was therefore taken of the opportunity of obtaining a number of samples of small-holders' sheet coming from all parts of Malaya afforded us through the courtesy of the Committee of the Malayan Agri-Horticultural Association's Show held in August. The sheets were submitted for the All-Malayan Small-holders' Rubber Competition and are representative of the very best quality Malayan small-holding rubber, and almost all are of a quality equal to or even better than average plantation sheet. It was considered that a survey of the variation in vulcanising properties would be of value for comparison with that obtained from the investigation on the estate samples. Work on the subject was still proceeding at the end of the year.

The Influence of the Controllable Factors in the Preparation of Sheet Rubber

On the vulcanising properties

Information has been available for a long time concerning the influence on the vulcanising properties of changes in the various operations involved in the preparation of sheet rubber, but most of these studies used the simple rubber sulphur mix for testing purposes. Experiments have been carried out during the year in order to find out whether conclusions drawn from comparisons made in rubber sulphur mixes are in agreement with those to be drawn from tests in the A.C.S. "Captax" mix. It has been found that correlation between the results of testing in the two mixes is good. There is evidence to show that rubbers which are considered from rubber sulphur tests to have been made faster

*Planted areas over 100 acres.

curing as a result of alterations in preparation treatment, are also considered faster curing when tested in "Captax" mixes, and conversely.

The influence of the use of various amounts of different anti-coagulants, acid for coagulation, amount of machining, washing and soaking which the coagulum can receive, together with experiments on the drying of the wet sheet, have been studied. The experiments were still in progress at the end of the year but it appears that the conditions of drying can have a big effect on the vulcanising properties of the sheet.

On the ageing properties

In conjunction with the above work on the vulcanising properties, the influence of the drying conditions on the oxygen-bomb ageing properties in an accelerated mix of the diphenyl-guanidine type have been studied. In view of the published findings that hot-air-dried sheet shows inferior ageing properties to smoked sheet when tested in rubber sulphur mixes, similar experiments have been repeated using D.P.G. mix. The same conclusions were obtained; moreover in these experiments, where sheet was dried in a combination of smoke and hot air, the ageing properties were worse when the preliminary drying took place in smoke and the final in hot air, than the converse case where the preliminary drying was made in hot air and the final in smoke.

Plasticity and Fundamental Work on the Causes of its Variability

The plasticity of commercial rubbers

It was recorded in the last report that work was in progress to test the opinion held by certain users that dark coloured rubbers are usually soft and light coloured rubbers hard. This work was completed and its results communicated in a paper presented at the Rubber Technological Conference held in London in May 1938.

The work has shewn that considerable variation in the plasticity of plantation sheet rubber exists, but it was also concluded that the generalisation cannot be made that depth of colour is correlated with plasticity. Some evidence was however given, that among samples made from the same latex the darker samples were the more plastic, although hot-air-dried sheet was not the least plastic. Attention was drawn in this paper to the need for further investigations on the correlation of laboratory plasticity tests and the behaviour of the rubber in the factory.

The plasticity of clonal rubbers

In view of the variation in plasticity of commercial smoked sheet which exists, it is necessary to determine how much of this variation is due to factors which can be controlled by the producer, and how much is beyond his control because of inherent differences in latices. During the year extensive work has been carried out on the plasticity of the clonal sheet rubber from Block 5 and it is hoped to collate and publish a full account of this work very shortly. The following conclusions however, may be recorded here:—

(a) There are significant and large differences in the plasticities of the sheet rubber prepared in identical manner from the nine clones.

(b) There is little evidence of seasonal effect on the plasticity.

(c) Rubber from clones P.B. 186 and Avros 152 is outstandingly soft.

(d) The rubbers all tend to harden on storage and the rate of hardening for the soft rubbers is greater than for the hard ones.

(e) After two years' storage P.B. 186 and Avros 152 rubbers have hardened considerably, but the relative order of softness among the nine clones is unchanged. The harder rubbers still require 60 to 70 per cent more mastication than either of the soft ones to bring them all to the same degree of softness used in the mastication tests.

The experiments were carried out on rubbers prepared from clones which were only in their second year of tapping, and it is possible that changes may occur as the trees age to modify the results now obtained. Confirmatory evidence has been obtained in the case of clone P.B. 186 by the courtesy of the management of Prang Besar Estate, to show that rubber prepared from the latex of the original buddings, propagated from the mother tree and now in their twelfth year of commercial tapping, is equally as soft as that from the young trees on the Experiment Station. It is interesting to note in this connection that the soil in which these old buddings are growing is of very different type from that in Block 5.

Rubber from individual trees

On account of the big differences in plasticity which occur among clonal rubbers the investigations on the variation in plasticity of the rubber from individual trees have been extended during

the year. A survey was made of the plasticity of the rubber prepared from a number of different trees in a block of young seedlings on the Experiment Station. This area was brought into tapping in January 1936 at the same time as tapping was commenced in Block 5, to which it is adjacent. The preparation of the rubber samples was rigidly controlled and the differences observed must be due to inherent differences in the latex. The plasticity values obtained indicated that some of the trees, sometimes adjacent to each other, yielded rubber which was either harder and softer than any sample of sheet rubber yet tested. In order to ascertain whether such trees yielding exceptionally soft rubber can transmit this characteristic to buddings made from them the collaboration of the Botanical Division has been sought. Yield records have also been taken which will assist in the final selection of the most suitable mother trees from these soft-rubber trees and it is hoped early next year to establish buddings from them. So far as we are aware these will be the first attempts made to establish clones which have been selected on account of the inner properties of the rubber prepared from the latex rather than on account of their yields. It is unfortunate that so much time must elapse before the results of the experiments can be available.

The Influence of the Preparation Factors on the Plasticity of Sheet

Reference was made earlier in this report to the fact that among sheet samples made from the same latex the darker samples were the more plastic. At the close of the year investigations concerning the effect of most of the possible variations in the preparation treatment of sheet rubber which can occur in estate practice had been examined. So far evidence leads to the generalisation that preparation variations other than the drying treatment have little effect on the plasticity of the resulting dry rubber.

Fundamental Causes of Variability in Plasticity

The results of the investigations described above are indicative that variability in plasticity is largely due to inherent differences between latices, and it is evident that considerable variation does exist among seedlings within a small area.

Experiments carried out during the year show that there is no correlation between the acetone extract or the acid value and the plasticity. Sheet rubbers which differ considerably before extraction with acetone retain their relative differences when tested shortly after extraction, although a certain amount of hardening has occurred as a result of the extraction.

At the close of the year work was still in progress to obtain information on plasticity and its relationship to the caoutchol content of the rubber. Evidence has been obtained of which statistical examination makes it certain that good correlation does exist, but further work is required on this subject before it is desirable to say more.

The Drying of Rubber

Mention was made in the last report that work was in progress on the problem of "after dripping," a characteristic property of sheet which has been machined on high-speed batteries. Experiments were carried out at various temperatures to find out if there is a critical temperature at which sheet could be drained to avoid this "after dripping." No evidence was found that there is any such critical temperature, and although it appears that the texture of the wet sheet does not affect the rate at which moisture is lost during the first few hours of draining, it may affect the initial moisture content and therefore the amount of water lost. It has been shewn in a previous publication that there is evidence to indicate that initial moisture content varies with the square of the thickness of the sheet; and it appears likely that where the type of battery in use is such that a high initial moisture content is left in the drained sheet this phenomenon of "after dripping" is liable to occur. It is therefore now accepted that provision must be made for the removal of this water by drainage in the smoke-house rather than by evaporation.

The work on the experimental smoke-house of the Tunnel Type at the Experiment Station which was started last year has been completed. The difficulties which were originally encountered were finally overcome and the building was given a long period of trial under practical estate conditions. The results were satisfactory and it is now considered that houses of this type can be confidently recommended to estates. One of the principal points in design is that of the furnace, which in its present form has proved to be easy to control and capable of giving a good volume of smoke. This is an important point since it overcomes a difficulty which has always been associated with the furnace of the Subur type. The improvement is simple and can readily be incorporated in existing Subur furnaces, and has already been suggested to managers on several estates. At the close of the year one favourable report was available of an estate where the alteration had been carried out and the sheet was found to be somewhat darker following the improvements suggested.

An account of the development work together with an appendix giving details of this new type of smoke-house was published in the last number of the *Journal*. Two types have been described,

type A suitable for crops up to 1,000 lb. per day, and type B for crops up to 2,000 lb. per day. The design of the first follows very closely the experimental model and is considered to have been thoroughly tested and can be recommended to estates. Model B is designed on exactly the same principles as type A except that eight trucks of a slightly modified design instead of four are used on a single track. This model has not yet been put into operation as means for testing it are not available at the Experiment Station, but it is hoped that an estate will be found needing a house of this size and will erect such a building in which tests can be made by the Institute for early publication. At the close of the year one estate was known where a type A house was in course of erection, and from the volume of correspondence and enquiries received on the subject, it would appear that several other estates are contemplating the erection of similar smoke-houses.

Storage of Sheet Rubber

The recent arrangement which permits estates to build up larger stocks of rubber during the period of low export release brought the subject of storage very much to the fore. Numerous enquiries were received on the subject and complaints made of defective smoked sheet following the use of para-nitrophenol as a mould preventative. Advisory work indicated that these complaints arose in places where higher drying temperatures were used. Experiments were carried out which showed that rubber containing para-nitrophenol was more susceptible to damage by overheating, particularly in the early stages of drying, than the controls which were untreated. A short paper on the prevention of mould growth on sheet rubber during storage was published in the last number of the *Journal*.

At the end of the year experiments were in hand with a view to testing the possibilities as mould preventatives of Santophen 20S and certain other bactericides. It does not appear however as if they will be suitable for this purpose in the preparation of sheet rubber, but they may be of value in the manufacture of pale crepe owing to the fact that para-nitrophenol should not be used when this type of rubber is being prepared.

Sheeting Batteries

During the year an improvement on the "Guthrie R type" battery has been evolved by Mr. Reginato of Ulu Tiram Estate, who was responsible for the original design. The new battery known as the "Guthrie Aristo" is similar in design to the "Guthrie Cadet" as it consists of a single compact unit, but has five pairs of rolls instead of four. By the use of multiflat-faced

rolls in all but the marking rolls the efficiency of the "Cadet" has been improved, whilst the performance of the "Aristo" is superior to that of the older "R type" which it now supersedes. It is understood that conversion of the "R type" to the new "Aristo" form is easily carried out, and that a number of estates equipped with the older batteries are now having them converted.

Advisory Work and Routine Chemical Examinations

The appendix to the Director's report gives a statement of the Divisional correspondence, from which it will be seen that over 1,400 letters were despatched from the Division during the year; this is a substantial increase over last year's figure. Many estate enquiries were received concerning latex preservation and testing, together with considerable correspondence on faults in smoked sheet and their remedies, for which the increase in the number of outbreaks of mould growth during the storage of sheet rubber on many estates was largely responsible. Over 600 specimens and samples were received for examination or analysis; the large increase over last year's figure is accounted for by the inclusion of the samples received for the vulcanisation survey. The number of visits paid to the Division by estate managers and other visitors was 368, whilst 99 visits were paid to places other than the Experiment Station. Twenty-one tours of advisory visits were made during the year including tours in Kedah and Johore, and whilst on a visit to Indo-China, Mr. Piddlesden was privileged by the courtesy of the directors and managers concerned to visit many of the large rubber estates in that country. The impressions obtained, particularly with regard to estate factory equipment and operation, were published as a note in the last number of the *Journal*. Considerable interest has been taken in the new tunnel smoke-house and numerous enquiries have been received by personal visit and correspondence for information and reprints of the paper published in the *Journal*.

Collaboration with Allied and other Organisations

The usual close contact has been maintained with the scientific officers of the London Advisory Committee throughout the year. Samples of special types of latex and rubber have been sent to them for their tests and further action in England if required. Their assistance together with their help in negotiating patent applications on our behalf is gratefully acknowledged. A further step towards the mutual understanding of the various problems which are encountered both here and in Europe, was made by the visit of Mr. W. S. Davey of the Committee's Scientific Staff in London, who made a tour of the rubber-producing countries of

the East and spent some time with us. Opportunity was taken to discuss with him various points in connection with testing technique, and he was able to see the methods used in the laboratories here, while officers of the Chemical Division accompanied him on tour during his stay in Malaya.

Liaison has been established between the newly-formed British Rubber Producers' Research Association, and we have already been able to assist them by supplying certain raw materials required for their investigations.

The cordial relationships which have always existed between the scientific officers of the B.F. Goodrich Research Station in Kuala Lumpur have continued throughout the year, and grateful acknowledgment is made of the assistance and discussion which has been willingly afforded to us at any time.

Correspondence with the officers of the Ceylon Rubber Research Scheme has occurred whenever points of mutual interest have arisen.

Lectures

The following lectures were given during the year:—

Lecturer	*Place*	*Title*
E. Rhodes ...	Johore North Incorporated Society of Planters Branch, at Genuang, Johore	"From Raw Rubber to the Manufactured Article."
J. H. Piddlesden ...	Central Johore Incorporated Society of Planters Branch, at Kluang, Johore	- do -
J H. Piddlesden ...	Kuala Lumpur District Planters' Association, at the Selangor Club Card Room	- do -
V. H. Wentworth ...	Central Perak Incorporated Society of Planters Branch, at Ipoh, Perak	- do -

V. H. Wentworth ...	Batang Padang District Estates Asiatic Staff's Association, at the Tamil School, Sungei Kruit Estate, Sungkai, Perak	"From Raw Rubber to the Manufactured Article."
V. H. Wentworth ...	Sitiawan Incorporated Society of Planters Branch, at Lumut Rest House	- do -
J. H. Piddlesden ...	Kedah Planters' Association, at Sungei Patani, Kedah	"The Preparation of Smoked Sheet."

Publications

(i) Papers

Selection of Rubber Factory Equipment

by J. H. Piddlesden

J.R.R.I.M. **8** (1938) 163

The Constituents of Hevea Latex

Part II by K. C. Roberts *J.R.R.I.M.* **8** (1938) 179

Part III by K. C. Roberts *J.R.R.I.M.* **8** (1938) 187

Part IV by K. C. Roberts *J.R.R.I.M.* **8** (1938) 192

Plasticity and the Colour of Sheet Rubber

by J. D. Hastings

Rubber Technological Conference London, May, 1938

Reprinted *J.R.R.I.M.* **8** (1938) 291

The Constituents of Hevea Latex

Part I by K. C. Roberts *J. Chem. Soc.* (1938) 215

Part II by K. C. Roberts *J. Chem. Soc.* (1938) 219

Reprinted as *Constituents of Hevea Latex*

Part V and Part VI *J.R.R.I.M.* **8** (1938) 308 and 315

Prevention of Mould Growth on Sheet Rubber during Storage

by J. D. Hastings and J. H. Piddlesden

J.R.R.I.M. **8** (1938) 250

Experiments with a New Type of Smoke-house

by J. H. Piddlesden

J.R.R.I.M. **8** (1938) 258

Latex Preservatives: 1. Some Preliminary Experiments with Sodium Pentachlorphenate—"Santobrite"

by Edgar Rhodes

J.R.R.I.M. **8** (1938) 324

Notes on a Visit to Indo-China

by J. H. Piddlesden

J.R.R.I.M. **8** (1938) 331

(ii) Warnings

Dangerous Bale Strappings for Rubber—A Warning

by Edgar Rhodes

J.R.R.I.M. **8** (1938) 290

(iii) Patent Texts

Creaming Latex with Synthetic Creaming Agents

by Edgar Rhodes and K. C. Sekar

J.R.R.I.M. **8** (1938) 343

Creaming Latex with Tamarind Seed Powder

by Edgar Rhodes and K. C. Sekar

J.R.R.I.M. **8** (1938) 346

(iv) Book Reviews

Polymerisation and its Applications in the Fields of Rubber, Synthetic Resins and Petroleum

by K. C. Roberts

J.R.R.I.M. **8** (1938) 217

The Chemistry and Technology of Rubber

by Edgar Rhodes

J.R.R.I.M. **8** (1938) 219

Synthetic Rubber

by Edgar Rhodes

J.R.R.I.M. **8** (1938) 355

The Chemistry and Technology of Rubber Latex

by J. H. Piddlesden

J.R.R.I.M. **8** (1938) 356

Latex and Rubber Derivatives and their Industrial Applications

by K. C. Roberts

J.R.R.I.M. **8** (1938) 357

Annual Bibliography of Rubber Literature (excluding patents) 1937

by K. C. Roberts

J.R.R.I.M. **8** (1938) 362

Malayan Agri-Horticultural Show

There was no Institute exhibit at the Show ground but as in 1937 the Institute was open to the public. Officers and assistants of the Chemical Division were on duty for discussion and demonstration to those interested.

Dr. Rhodes acted as judge with Mr. Moore and Mr. Meikle in the All-Malayan Small-holders Rubber Competition. The judging was carried out at the Institute and the exhibits were displayed at the Show.

Empire Exhibition Glasgow 1938

Chemical Division Officers were responsible for the despatch of the scale model of the rubber factory to the Malayan exhibit of the above Exhibition, and gave organising assistance to the artists responsible for the rubber estate diorama.

J. D. Hastings

Ag. Head of Chemical Division

Kuala Lumpur,

23rd February, 1939

ANNUAL REPORT

EXPERIMENT STATION

1. Acreage Statement

Planted	1,126.36	acres
Building Sites and Roads ...	65.36	„
Elephant Belt } Reserve Jungle }	159.78	„
	1,351.50	„

Planted:

in bearing on 31.12.1938 ...	753.63	acres
Immature (including nurseries)	372.73	„
	1,126.36	„

N.B.—Not included in the above acreage statement are two Seed Gardens, totalling 10 acres, in the Forest Reserve, held under permit. These areas are reserved for work on *Hevea spruciana.*

During the year under review a survey of the Station was carried out by a qualified surveyor, and acreages as now stated are the corrected ones.

2. Distribution of Land

Botanical Division	817.78	acres
Soils Division	292.58	„
Pathological Division	16.00	„
Chemical Division	—	„
Building Sites and Roads ...	65.36	„
Jungle and Elephant Belt ...	159.78	„
	1,351.50	„

Experimental work on latices from various types of material, and various tapping systems, is carried out on a number of the blocks* by the Chemical Division.

The Pathological Division carry out routine pest and disease inspection and treatment all over the Station.

* The areas referred to as "Blocks" in this report, have since been renamed "Fields", and are so described in the reports of Divisions.

3. Clearing

During 1938 a total of 85 acres of jungle was prepared for planting on the following lines:

Block 34. 45 acres

On this area of extremely hilly land at the southern end of the Station the jungle was felled on the contour and, three weeks later, a light scorch-burn was put over the clearing. After lining on contour had been done, strips 6′ wide along the planting lines demarcated were cleared of all lying timber and stumps up to a diameter of 8″ were removed.

Block 35. 30 acres

On this area of hilly land an experiment was started on the girdling and poisoning of jungle trees and preparing for planting with a minimum amount of clearing, compared with orthodox methods of felling, burning and planting.

The area was laid out on a randomised system with three plots of five acres treated as above and with three plots of five acres each, which is felled and scorch-burnt as is the normal practice. The lay-out is as follows:—

A	B	B	A	A	B

A = normal treatment B = frill-girdling and poisoning

Prior to any felling etc. being done, square lining at 22′ intervals was carried out in the jungle and rentices 6′ wide were completely cleared of all lying timber and *belukar*. Next, stumping up to 8″ diameter was carried out along the cleared rentices. The jungle in the normal-treatment blocks was now felled and after three weeks was scorch-burnt. The co-operation of the Forest Department was now obtained and Mr. Walton and some Forest Department labourers came and frill-girdled and poisoned all standing trees in the B plots, at a height of 3′ from the ground. All small *belukar* was slashed and was well pressed down. No felling is being done in the poisoned areas and it will be interesting to see how the results compare with the control areas. There are still a few large trees carrying canopies but it is not anticipated that they will refoliate after the wintering season. The poison used for this trial was sodium arsenite.

Block 36. 2 acres (Nursery)

An area of two acres for a manurial trial on seedlings and buddings was felled, clean-cleared, and dug-over to a depth of 2′ and levelled. On completion of this work beds 38′ × 9′ were prepared.

Block 37. 8 acres (Test-area of Chemical Dusts and Sprays)

The jungle on this area of poor soil, which is liable to flooding, had been felled earlier in the year. Later, in October, the area was taken over by the Pathological Division, and was cleared and planted at a spacing of 20′ × 2½′. The area is adjacent to the frill-girdled and poisoned part of Block 35, so it was not possible to do any burning. Lining was done at 20′ spacings and rentices 6′ wide were cleared and stumped up to 8″ diameter.

4. Lining, Holing and Planting

Block 34. 45 acres

Lining was done on contour to allow for a spacing of 20′ × 10′, giving 217 plants per acre. Terraces 6′ wide on the reverse-V-slope system were cut, and 2′ stops of uncut earth were left between each plant. Holes 2′ × 2′ × 1½′ were cut and these were later filled with good top-soil. The planting material used was three germinated seed and one basket plant per point. No manuring was done for the rubber plants.

This area is reserved for the establishment of our newest hand-pollinated material.

Block 35. 30 acres

Despite the fact that this area is steep it was decided to try and obtain as much uniformity as possible. Lining was done square at a spacing of 22′ intervals. In the control (A) plots the spacing was 22′ × 11′, giving 180 trees per acre, and in the poisoned (B) areas the lining was 22′ × 5½′, giving 360 trees per acre. No felling was done in the frill-girdled and poisoned areas, so it was considered necessary to have a high stand of trees to allow for later losses by the falling jungle trees. Holing was done 2′ × 2′ × 2′ in the control plots and 1′ × 1′ × 1′ in the poisoned areas. The planting material was clonal seedling stumps and these have been established on a randomised lay-out. Planting was completed by the end of April, and again no manuring of the rubber plants was done.

Block 36. 2 acres (Nursery)

In this nursery the randomised lay-out consists of 96 beds with 171 plants per bed. The material is germinated seed and the planting spacing is 2′ × 1′. A further 24 beds having 171 plants per bed have been planted with budded stumps. These stumps are budded with Pilmoor B. 84 budwood and have also been established at a spacing of 2′ × 1′. The area surrounding these two nurseries has been planted with seedlings and budded stumps respectively, to counteract any "boundary effect."

The object of this experiment is to ascertain the effect of manures on budding successes, when applied at varying times before and after budgrafting and to ascertain the effect of manures on nursery budwood.

Block 37. 8 acres

Lining was done at a spacing of 20′ × 2½′. The material used was basket plants one per point and germinated seed. The area is earmarked for dusting tests with various chemicals.

5. Nurseries

Block 1. (Main Multiplication Nursery)

Multiplication of various materials from our hand-pollinated crosses was carried out during the year. Large quantities of budwood were cut and despatched to estates co-operating with the Rubber Research Institute on experimental plantings.

Block 4. 5 acres

The few remaining beds of budwood in this nursery were eradicated and these areas were dug over, levelled and had a leguminous bush cover planted. In December the area was lined 10′ × 10′ and after holing had been done it was planted, on a randomised system, part of the area being planted with budded stumps that had been treated with Hortomone A solution, and part with untreated budded controls. Manuring at varying depths was also done on part of the area.

Phosphate Experimental Area. ½ acre

This area was planted with seed at stake just prior to the main dry season. Growth has been poor and uneven. Various grades of phosphates were put down, but the poor growth gives little hope of satisfactory results being obtained.

Clonal Seed Nursery and Despatch Shed

Large quantities of clonal seed were required for experimental plantings during the year. This material was partly collected on the Station and partly on estates co-operating with the Institute. Seed was sorted, germinated and despatched as required to various estates.

Surplus material was at the same time established in this nursery. To facilitate sorting, germination and despatch a shed was erected and in this shed, "boxed-beds" filled with coconut-husk dust were made. The seed was placed in this dust and was then covered with plaited coir mats. Watering was done only once daily. Germination was rapid and excellent.

Block 6A. Nursery of Clonal Seedlings and Buddings

Work on root study was carried out by Dr. Baptist during the year and results to date will be published under the Botanical Division Report.

6. Manurial Treatments

The standard mixture for 1937, details of which were given in that year's report, was changed; a soluble form of phosphate is now included.

The mixture used on the Station during 1938 was as follows:—

Sulphate of ammonia	5 parts	= N = 9.3%
Nicifos B	2 „	= P_2O_5 = 8.7%
X'mas Island rock phosphate	3 „	= P_2O_5 = 8.7%
Sulphate of potash	5 „	= K_2O = 16.8%

This fertiliser was applied on the following blocks with very satisfactory results.

Block	*Age of Rubber trees*	*Rate of application*
1 Multiplication Nursery ...		10 cwt. per acre
1A	... 3 years	1½ lb. per tree
2	... 10 „	2¼ „ „
3	... 8 „	2¾ „ „
4A	... 9½ „	2¼ „ „
4C	... 9 „	2¼ „ „
5	... 9 „	2¼ „ „

5A	... ...	1 year	$\frac{1}{4}$ lb.	per tree
9A	... ...	5 years	$1\frac{3}{4}$ „	„
10	... ...	7 „	3 „	„
12	... ...	2 „	1 „	„
13B	... ...	$9\frac{1}{2}$ „	3 „	„
14A & B	... ...	7 „	$2\frac{1}{4}$ „	„
14C & D	(Density experiment)	9 „	1–8 „	„
14E & F	... ...	7 „	$3\frac{1}{4}$ „	„
15	... ...	7 „	$2\frac{1}{4}$ „	„
15A	... ...	2 „	$\frac{1}{4}$ „	„
16	... ...	8 „	$3\frac{1}{4}$ „	„
16F	... ...	3 „	$1\frac{1}{2}$ „	„
17A	... ...	9 „	$2\frac{1}{4}$ „	„
17B	... ...	2 „	$1\frac{3}{4}$ „	„ ...
17C	... ...	7 „	$2\frac{1}{4}$ „	„
18A	... ...	6 „	$2\frac{1}{4}$ „	„
18B	... ...	6 „	4 „	„
19	... ...	8 „	$1\frac{1}{2}$ „	„
20	... ...	6 „	$1\frac{3}{4}$ „	„
21	... ...	7 „	$3\frac{1}{4}$ „	„
22	... ...	6 „	$3\frac{1}{4}$ „	„
23A	... ...	2 „	$\frac{1}{4}$ „	„
25	... ...	8 „	$3\frac{1}{4}$ „	„

Block 6. Manurial Trial. 40 acres Seedling Rubber. (R.R.I.E.S. Report for 1930)

The annual application of farmyard and artificial fertilisers was put down in April. The treatments received the following amounts of fertiliser:—

A.	Control	No manure	
B.	Complete Organic	56 lb.	Cowdung per tree
C.	„ Inorganic	$2\frac{1}{2}$ „	Enpekay No. 1 per tree
D.	Nitrogen	2 „	Sulphate of Ammonia per tree
E.	Phosphorus & Nitrogen	2 „	Nicifos B per tree
F.	Potassium & Phosphorus	$1\frac{3}{4}$ „	Sulphate of Potash and Double Superphosphate per tree

During this year the "Complete Inorganic" plots (C) lead in yields, with the "Potassium and Phosphorus" plots (F) next. The lowest yields are being obtained from the "Phosphorus and Nitrogen" plots (E), which are lower than the Unmanured plots (A).

The poor foliage in the "Nitrogen and Phosphorus" plots emphasizes the potash deficiency of the soil on this area.

Block 23. 37 acres. A comparative test of Sterameal Young Rubber Mixture and Enpekay No. 1

The annual dressings of these two fertilisers were put down in April. Details of the lay-out of this trial will be found in the R.R.I.E.S. Annual Report for 1936.

Block 31. A Manurial Trial replicating Block 6 with Budgrafts. (R.R.I.E.S. Annual Report 1936)

The third and fourth applications of various fertilisers were applied as follows:—

A. Controls. No manure

B. 3½ oz. of Sulphate of Ammonia per tree

C. { 3½ oz. of Sulphate of Ammonia per tree and
   { 2 oz. of Sulphate of Potash

D. 4¼ oz. of Nicifos B per tree

E. { 2 oz. Concentrated superphosphate per tree and
   { 2 oz. Sulphate of Potash

F. 6 oz. Enpekay No. 1 per tree.

Block 13 A. (R.R.I.E.S. Annual Report 1937)

A. plots 6 oz. of Enpekay No. 2 per point
B. „ 6 „ „ „ 2 „ „
C. „ 6 „ Complete Inorganic per point
D. „ 6 „ Enpekay No. 2 „ „

These fertilisers were applied in March, and then the area was budded in December with Tjirandji 1 budwood.

Block 14 C and D. Density-of-Planting Experiment. (R.R.I.E.S. Annual Report 1936)

The badly retarded plot in this randomised lay-out was manured in March. Growth of the rubber trees is still very poor.

Block 17 D. North. Manurial Trial on Clonal Seedlings. (R.R.I.E.S. Annual Report 1937)

The following fertilisers were applied in October:—

A. Controls. No manures.
B. 19 oz. Sulphate of Ammonia per tree.
C. 19 oz. Sulphate of Ammonia + 22 oz. superphosphate per tree.

D. 19 oz. Sulphate of Ammonia + 10 oz. Sulphate of Potash per tree.
E. 19 oz. Sulphate of Ammonia + 22 oz. Superphosphate + 10 oz. Sulphate of Potash per tree.
F. 22 oz. Nicifos B. per tree.
H. 19 oz. Sulphate of Ammonia + 16 oz. Crushed Limestone per tree.

A very noticeable improvement in the colour of the foliage can be seen in the E and D plots. In the E plots the complete inorganic treatment has resulted in an excellent growth of new branches and large leaves. Growth in the C and H plots is very poor, being no better than the controls.

Blocks 32 and 33. 60 acres. New Clearings. (R.R.I.E.S. Annual Report 1936)

On these clearings the R.R.I. Standard Mixture for 1938, mentioned above, was put down. On the first application at planting 6 oz. of fertiliser were put down per hole, and then in May a second application at the rate of 3 oz. per point was given.

Block 17 C. 6 acres. Replanting Experiment

It was decided to replant this area as losses caused by termites and root disease had been serious. Planting was done in September with four germinated seed per point and Standard Mixture was put down in the holes at the rate of 2 oz. per point.

Block 16 F and 1A. 5 acres

The buddings on these two areas were seen to be making poor growth. These areas, which had been previously clean-cleared for building sites, had suffered from much surface scorching of the soil.

R.R.I. Standard Mixture was applied in April, but as the foliage still showed signs of potash deficiency a second application of sulphate of potash at the rate of 1 lb. per tree was put down in early December.

Cover-Crop Manuring Trials

Block 5. 40 acres. Latin-Square Lay-out of Buddings

On this area of nine-years-old buddings the original cover of Centrosema and Pueraria had died out and an attempt was made to establish another leguminous cover. A special fertiliser mixture was made up of:—

2 parts Sulphate of Ammonia
1 „ X'mas Island Rock Phosphate

1 part Concentrated Superphosphate
1 „ Sulphate of Potash.

This fertiliser was broadcast over the field at the rate of 2 cwt. per acre, and then cuttings of *Desmodium ovalifolium* were established 3′ × 3′ apart.

Block 20. 20 acres

The *Crotalaria anagyroides* and *Desmodium ovalifolium* in this field had a dressing of rock phosphate applied at the rate of 2 cwt. per acre.

Nurseries

All the nurseries were regularly manured with a special mixture suitable for this type of soil. In the hand-pollination nursery, the seedlings were manured at regular intervals with liquid cowdung.

7. Soil Exhaustion Experiment

Block 23. (R.R.I.E.S. Annual Report 1936)

Twenty-nine acres in this Block not required as a manurial trial continued to be tapped as an experiment on latices derived from various tapping systems.

8. Thinning Out

Test-tapping was carried out in the following Blocks and then thinning-out was done:—

Block	*Acreage*	*Stand per acre* 1937	1938	*Material*
17 D. South ...	9 acres	180	125	Polyclone area (mixed buds and seeds. 22′ × 11′)
19 (Cultivation experiment) ...	9 „	180	140	Monoclone. B.D.5. (22′ × 11′)

9. Roads, Bridges and Drains

Roads and Bridges

A new road was made from Block 18, towards the southern end of the Station for a distance of 40 chains. This road leads to Blocks 34, 35, 36 and 37, opening up a total of 85 acres.

On the road along the western side of Blocks 30, 31, and 33 two sets of culverts were removed, as these were causing trouble

by sinking in the soft sand. Two hardwood bridges were erected in their place and these are functioning satisfactorily.

The main road system over the Station was upkept and metalling of portions was done where necessary.

Drains

The main drainage system was cleaned and the anti-malarial system was upkept at regular intervals. Flooding occurred near the jungle outlet in Block 19, so sand was dredged from the stream and all pockets were filled. No further trouble is now being experienced from this area and the amount of oil now used is considerably reduced.

10. Terracing, Silt Pitting and Bunding

Terracing. Block 34. 45 acres (New Clearings 1938)

Reverse-V-slope terraces 6′ wide were cut on the contour at 20′ intervals by Tamils on check-roll. Timber lying between the contour was utilised to help make firm the front of the terraces. This method is not a satisfactory one, as much of the timber is soft wood and as this rots quickly breakages in the terraces are a common occurrence.

Block 35. Fitting and Bunding

The lining in this field is square 22′ × 11′, but as the land is steep, wash along the planting lines was anticipated. Pitting and bunding on contour at 20′ intervals was done in the control areas where normal felling and burning was done.

Block 19 and 24

Upkeep of the existing terrace system was done when necessary after heavy rains. The original cover of Centrosema and Pueraria had died sometime ago, but thanks to the system of 6′ wide terraces which were cut at the start, no serious trouble from erosion has occurred.

Block 27. 50 acres

Bunding was done along the clean-weeded inspection paths between plots on this area where slight erosion was noticed. Cuttings of indigenous covers and *Desmodium ovalifolium* were established on these bunds and erosion has now been successfully checked.

11. Cover Crops

Block 9. 8 acres. Rubber planted November 1928

An experiment was laid down to investigate the relative merits of three methods of establishing *Centrosema pubescens* in mature rubber areas, to determine the optimum amount of phosphate required for establishing and maintaining this cover under mature shade, and further to determine the effect of a cover of Centrosema on the growth and yield of the mature rubber trees.

The rubber is seedling material, and half the area has been surface-cleared of all timber and stumps, the other half being left unstumped.

The lay-out comprises a cover-cum-cultivation-cum-manuring trial. There are four cultivation treatments with replications:

A. Clean-weeding
B. Centrosema established in 1′ drills in each row
C. Centrosema established in 3′ drills in each row
D. Centrosema established in isolated beds 6′ × 3′ × 6″ (43 beds per acre).

For treatments B. C. & D. the earth was dug over to a depth of 6 inches. An initial dressing of 2½ lb. of sulphate of potash per tree square was applied and forked in strips 6′ wide over the whole area prior to the cultivation being done.

Later the following treatments with replications had phosphates applied:

Treatment	*Manure*	*Amount per plot of 21 trees*		
		At planting	*At 4 months*	*At 8 months*
1	Rock Phosphate	¼ cwt.	⅛ cwt.	⅛ cwt.
2	„	¼ „	¼ „	¼ „
3	„	¾ „	⅜ „	⅜ „
4	„	1 „	½ „	½ „

Nodule bacteria serum was prepared by the Pathological Division, and the inoculated seed of Centrosema was sown. Germination was excellent but later attacks from snails, slugs and rats caused trouble. The area was then fenced and fresh seed was inoculated and sown.

The growth of the cover is poor, despite the application of phosphates. Root competition from the rubber rootlets would appear to be an important factor, for wherever the rubber trees are backward the cover grows well, but is seen to be dying off elsewhere.

Further details will be found in the Soils Division Annual Report.

Indigenous Covers

Indigenous bushy covers in Blocks 30, 31, 34 and 35 were slashed to 4′ when necessary. In Block 26, which is densely planted with clonal seedlings, the mixed indigenous stand of bushy covers has now come down to a mixture of *Hornstedtea* (Wild Ginger) and the fern *Nephrolepis biserrata*. These covers are to be found in our Forest Reserve, so it is hoped they will survive under mature shade conditions.

Block 12. 7 acres

The bushy covers on this area were becoming very woody and were cut back to below ground level; later cuttings of *Clitoria cajanifolia* were put down in their place. This cover grows well on our sandy soil.

Root Nematode (Eel Worm)

On a number of areas on the sandy flats of the Station, where *Desmodium ovalifolium* was planted, Root Nematode attack is marked and the cover is dying off. Most of these areas were planted with cuttings taken from our main cover-crop nursery in a swampy area, and it appears likely that these cuttings carried the pest, as it is also prevalent in the nursery. An area near the office which was planted with seed shows no sign of eel-worm attack.

This problem is being investigated by the Head of the Pathological Division.

Competition from Leguminous Bushy and Indigenous Covers

In Blocks 32 and 33, comprising an area of 60 acres, serious retardation of the rubber plants was noted at an early stage. The rubber in these fields had had 6 oz. per point of complete inorganic fertiliser applied at planting. The covers consisted of a mixture of indigenous bushy covers and *Tephrosia candida* established between the rows, with *Desmodium* planted along the planting lines. The *Desmodium* was kept ring-weeded to 3′. When retardation was noticed, inspection pits were dug along the edges of the planting rows and roots of the *Tephrosia candida* and the Wild Cherry (*Trema angustifolia*) were found to have travelled in from 12′—14′ away and these roots were massed in the planting holes. Instructions were received to keep the covers slashed to 2′ and to carry out "slicing," to a depth of 8″ along the edges of the planting rows, alternate-monthly. The *Desmodium* was also pulled back and kept ring-weeded to 6′. The growth of the rubber is now excellent.

This competition has not been nearly so marked on natural cover areas on which no manuring of the rubber was done.

Cuttings treated with Hortomone A

Mr. Kaimal of the Botanical Division is at present working on a method of treating cuttings of indigenous covers with Hortomone A solution. He is also carrying out an ecological study of indigenous covers on our new clearings and observations will be reported on in that Division's report.

12. Rubber Trees Under "Forestry Conditions"

Block 11. 10 acres. (R.R.I.E.S. Annual Report 1935)

The tapping cuts were changed to a new panel at a height of 30" from the ground on 1-1-38.

Yields for the various treatments are as follows:—

Cleaned-up area	22′ × 11′ = 560	lb. per acre per annum
	22′ × 22′ = 387	„ „ „
Slashed controlled area	22′ × 11′ = 505	„ „ „
	22′ × 22′ = 366	„ „ „
Unslashed area	22′ × 11′ = 521	„ „ „
	22′ × 22′ = 388	„ „ „

Root disease is still practically negligible in the two "forestry" treatments, but is prevalent in the cleaned-up area. Termites cause trouble in the natural-cover areas.

It is noticed that the density of the stand of *belukar* in the unslashed areas is considerably reduced. No signs of Mouldy Rot were noted during the year.

During the dry spells experienced through the year the yield in the cleaned-up area fell, whilst the yields in the two natural-cover treatments showed no decrease.

13. Soil Erosion Experiment.

Block 24. 4 acres

Annual manuring of this block and subsequent measurements of soil movement were discontinued as the covers have all died off as shade and root competition have increased.

14. Cultivation

Alternate-monthly weeding and forking in the 8′ rings round young plants up to three years of age is still being carried out.

Slashing close to ground level of the fern *Nephrolepis biserrata* in the swampy areas of Blocks 18, 19 and 22 has killed most of this cover.

Block 19. 6 acres

The work of digging-in grasses etc., in the demarcated plots was carried out twice during the year. Growth measurements have been taken by the Soils Division.

Desmodium ovalifolium planted in the swampy area has been attacked by eel-worm and is dying back. An attempt is to be made to establish in this infected area certain other covers which it is hoped will be free from attack by this pest.

Block 25. Leguminous Bushes, Creepers and Grasses. 8 acres

Regular rounds of slashing have been carried out to schedule during the year. The leguminous bushes (Lamtoro) are tending to become rather woody.

15. Pests and Diseases

Routine rounds of inspection and treatment for all diseases were carried out during the year over the whole Station.

Details of Cases Treated

Disease	*Trees treated*	*Trees removed*	*Total*
Fomes lignosus ...	1,095	415	1,510
Ganoderma pseudoferreum	98	77	175
Fomes noxius ...	45	25	70
Ustulina zonata ...	28	20	48
Termites ...	2,384	256	2,640
Pink Disease ...	2,448	—	2,448
Lightning ...	5	8	13

The treatment carried out for root disease attack is the same as that mentioned in the R.R.I.E.S. Annual Report 1933.

The treatment recommended for Pink Disease has been slightly altered. The present recommendation is that for the first three years a water-miscible fungicide such as Izal be used, and that to facilitate supervision a colouring matter such as red ochre, etc., be added to the solution. After the third year Asphaltum-kerosene and Brunolinum treatment is recommended.

Treatment for termites was intensified during the year, each field being sub-divided into four parts, and on each part a different insecticide was tested:

Plot 1 Opening up round the collars of affected trees and treating them with Cymag and sodium silicofluoride.

Plot 2 Injecting a proprietary arsenical dust into the earth runs on the affected trees.

Plot 3 Injecting commercial white arsenic powder into the earth runs on affected trees.

Plot 4 Pouring mercury perchloride solution into the earth runs on the trees. The runs were broken open at the upper ends, but otherwise damaged as little as possible.

A discussion of the relative efficiency of the different treatments is given in the report of the Pathological Division.

One of the proprietary arsenical dusts tested during the year caused severe burning of the bark during wet weather. The makers have been notified and a new type of filler is being prepared, after which further tests will be carried out.

The hand guns used for methods 2 and 3, are not too satisfactory and attempts are being made to produce a more efficient type.

Lawana conspersa. (Mealy Bugs)

A slight attack by this pest was experienced in Block 12, the attack being on the leguminous bushy covers only. Dusting with Cymag powder proved most satisfactory and no recurrence of the trouble was recorded.

A number of trees in Block 2 were seen to have their leaves attacked by a silvery scale-insect. Specimens were taken to the Pathological Division and later it was reported that this attack was caused by *Chionaspis* sp.

No recurrence of this attack occurred.

Caterpillars. (Achaea prodenia sp.*)*

These pests made their annual appearance from the jungle on the western side of the Station, being found on the natural covers and rubber trees in Blocks 30, 32 and 33. Immediate spraying with a lead arsenate solution put a stop to this trouble and little defoliation occurred.

16. Jungle Plots *A* and *B*

Seed of *Hevea spruciana* was collected and is being established temporarily in the main multiplication nursery; it will later be used for a replanting experiment in the swampy area of Block 18.

In Jungle Plot A signs of erosion were noted and the area was contour-bunded.

Regular rounds of weeding, *lalang* patrol, and pests and diseases inspection were carried out during the year.

17. Weeding

All "forestry" blocks were weeded monthly, and forking was done in the circles round trees alternate-monthly in Bls. 30, 31, 32 and 33.

Block 27. The usual system of keeping the terraces clean-weeded was stopped and circle-weeding only was done from June onwards. It was noticed that the width of the clean-weeded strips had increased to 8′ and it was seen that slight erosion was occurring, so the *belukar* etc., is being allowed to encroach to 6′ again. The indigenous covers in treatments 3, 4 and 5 were slashed back twice during the year.

New Clearings. Weeding was done monthly. The terraces were kept clean-weeded and between the terraces *Centrosema pubescens* and natural growths are allowed to establish together. All grasses, indigenous creepers and noxious growths are eradicated on sight. *Bertam attap* was beaten monthly by the weeders and is now practically non-existent on the clearings.

Block 35

In the control areas monthly weeding along the 6′ planting lines was carried out and *Centrosema* and indigenous covers were allowed to establish between the rows.

In the frill-girdled-poisoned areas, rough rentices 4′ wide were cleaned twice during the year, *belukar* attempting to establish on these planting lines being cut off below ground level. Two rounds for eradication of grasses were carried out, but no other attempt at weeding or control of the *belukar* has been done.

Mature Areas

On these areas, depending on the density of the covers, weeding was done alternate-monthly or quarterly only.

Lalang

Routine patrols for the eradication of *lalang* were carried out in Blocks 5A, 15A, 23A, 27 and 32, and on the new clearings, Blocks 34 and 35. Quarterly rounds were carried out in Blocks 26, 28, 29, 30, 31 and 33. Over the remainder of the Station sporadic *lalang* seedlings seen are removed by the weeders.

Slashing Building Site

The compounds and building sites were slashed monthly. Slashing of drain edges in the anti-malarial area has been done when necessary.

18. Budgrafting

The following fields were budded or had budded material established in them:

Block 13 A. 2½ acres. Budded with Tjirandji 1.
„ 4 B. 2 „ Planted with budded stumps of Pilmoor B. 84.

Rebudding of supplies and failures was carried out in Blocks 5A, 17B, 28, 29, 30 and 31.

In Block 1 Main Multiplication Nursery, 46 new seedling beds were budded with various materials and 3,000 successful buddings were made for distribution to different Agricultural Stations.

Demonstrations in budgrafting technique were given to A.R.Is., Visiting Planters and Conductors.

The waxed-cloth method is still preferred as it gives the most uniform results.

19. Hand-pollination

Artificial hand-pollination of various clones was carried out by Mr. Sharp of the Botanical Division during the year, in Blocks 4A, 5, 15, 17 and 14. In all 4,043 pollinations were made and 987 seed were obtained, and have been established in the hand-pollination nursery.

The 1937 hand-pollinated seedlings have grown well and the material from this planting is to be used for establishment in Blocks 32 and 33 as buddings with seedling controls.

20. Experimental Test-Tapping

Block 9A

Test-tapping of the material in this block of two acres was carried out for the first time. Trees of adequate girth were tapped for ten days, the crop from the last five days being cup-coagulated and weighed.

Blocks 20 A and 26

These blocks received similar treatment to Block 9A. Yield figures will be published by the Botanical Division.

Block 5

This block of 40 acres with nine clones randomised with four replications had previously been on half-spiral a.d. tapping. In February each plot was subdivided into three sections, and the following tapping systems were employed:

A. 3 Rows. a.d. left half-spiral
B. 3 „ d.a.m. left half-spiral
C. 3 „ a.d., A.B.C. left half-spiral 6 months tapping and 3 months rest.

Block 6 Boundary Rows

The experiment laid out by Mr. Kaimal on the guard rows in each plot of this manuring experiment was continued.

The systems of tapping are:—

a.d. Left half-spiral opened at 20″
a.d. „ „ „ at 40″
a.d. Two cuts at 20″ and 40″ on opposite sides of the tree, 3 months tapping and 3 months rest.
Full-spiral fourth-daily with no rest.

Blocks 22 and 25

Experiments on opening trees at various heights are being carried out on seedling and budded rubber in these blocks. Results for all these trials will be published in the Botanical Division Annual Report.

21. Tapping

For details of fields in tapping see Annual Report R.R.I.E.S. for 1937.

The following fields came under the knife during the year:

Block	*Acreage.*	*Planting Distance Feet*	*Material*	*Tapping*	*Collection*
2 A	2	15 x 30	Buddings	Left half-spiral a.d. at 40″	Cup coagulation
10	8	22 x 22	Buddings at 1′, 2′, 3′ & 4′ with Seedling controls	Left half-spiral a.d. at different heights	Cup coagulation
17 D.N.	9	11 x 11	Clonal seedlings	Left half-spiral a.d. at 20″	Cup coagulation
18	69.5	20 x 20	Buddings from 16 clones	Left half-spiral a.d. at 30″ from ground level	Latex collected from each row separately
19 (Cultvn. expt.)	9	22 x 11	Buddings B.D. 5	Left half-spiral a.d. at 40″ from union level	Latex collected from each treatment separately
20 B	20	15 x 15	Buddings	Left half-spiral a.d. at 40″ from union level	Cup coagulation
22 A	9	22 x 22	Buddings	Left half-spiral a.d. at 40″ From May half-spiral at 20″, 30″, 40″ and 50″ from union on the opposite side	Cup coagulation
25 Sec. 3		20 x 20	Twins	Left half-spiral. Daily at 20″	Cup coagulation

22. Curing

During the year the details of crops harvested and treated are as follows:—

1.	Ribbed Smoked Sheet ...	138,835 lb.
2.	Pale Crepe	1,005 „
3.	Compo Crepe	29,696 „
4.	Cup-coagulated lumps ...	154,115 „

Pan-coagulation was carried out for latex from fields 5 centre, 6 centre, 14 C and D Centre, 14 F, 18 A, 19 Cultivation plots.

Latex from fields 2 A, 4 A, 4 C Seedling, 7, 8, 9, 11 14 C and D Bdy., 16, 18 B, 18 C, 18 Seedling, 19, 21 Bdy., 23 and 24.

Demonstrations in sheet manufacture were given to A.R.Is. and Visiting Conductors.

All the crop harvested is sold locally to a Chinese dealer, and good prices have been obtained during the year.

Details of tapping are as follows:—

No tapping for 23 days.
Late tapping for 69 days.
Rain interfered for 29 days.

Standard Production 310,000 lbs.

Cup Samples

During the year all cup lump samples were collected, dried and weighed. Records of the weighings were returned to the Botanical Division. There are approximately 32,500 samples to be weighed each month.

Smoke-houses

During the early part of the year, the Small Devon and the large Kampong Type smoke-house, of bamboo lined with brown paper, were in use. Experiments were carried out on an improved type Tunnel smoke-house. Results have proved very satisfactory and the Tunnel smoke-house is now recommended for estate use (*R.R.I. Journal* Vol. 8. No. 3).

23. Measurements

Girth measurements were taken by the Botanical Division Conductors in Blocks 2, 3, 4A, 5, 10, 4 A and B, 14 C and D, 14 E 1 and 2, 15, 16, 17 A, D and C, 22A, 25, 26, 28 and 29. Girth measurements were taken by the Soils Division Conductors in Blocks 6, 7, 8, 9, 11, 19, 23, 25, 27 and 31. Records were sent to the respective Divisions.

24. Courses of Instruction

During the year five Europeans and 73 Conductors visited the Station and were given instruction for periods of a week to 10 days.

Ten planters, one from Borneo and one from Travancore, South India, spent two weeks on the Station.

25. Medical and Health

Health during the year has been good. During July a few of the labourers engaged on opening up the new clearing Block 34 contracted malaria, but these cases responded to early treatment.

Details of Labour and Health are as follows:—

Workers		*Dependents*	
Men	157	Men	2
Women	102	Women	8
Children	32	Children	94
	291		104

	Admissions to Hospital	*Treated on Station*
Malarial	—	17 cases
Injuries etc.	39	—
Confinement	13	—
Deaths	2	

Spleen Rate for the year:		
	Men	1.6%
	Women	2.1%
	Children	2.6%

The special method of brush-cum-spray oiling employed on this Station has been carried out during the year with satisfactory results. A total of 773 acres is oiled each month and costs for the year for labour and oil are $254.35 and $65.37 respectively.

Our thanks are again due to our Visiting Medical Officers, Drs. Cameron, Mackintosh and Hardie for their advice and assistance.

Through the courtesy of the Directors of the Kepong Group Hospital permission was obtained for sick labourers from this Station to be admitted to that hospital. This will save the Station a considerable sum each year on transport, as previously labourers had to be taken to the General Hospital, Kuala Lumpur.

26. Rainfall

The rainfall during the year was 81.12 inches, which is about 25 inches below the average for the past ten years.

27. Building and Machinery

A new 4,000-gallons tank and tower was erected at the factory for extra storage of water.

The old system of wedge cocks on the pipe line was dispensed with and new full-way cocks were inserted.

Two hills over which the main pipe line from the reservoir cross were found to be impeding the full flow of water. Trenches 10′ deep were cut through these hill tops and the pipe was lowered into them. Water is now being obtained with good pressure at the lines and bungalows.

No new machinery was purchased during the year. The existing plant is working satisfactorily.

Buildings

The following new buildings were erected during the year:

1. One additional bedroom and bathroom at Bachelor Conductors' Quarters, for the Soils Division Conductor.
2. One five-roomed building for the Chinese budgrafting Mandors of the Botanical Division.
3. One ten-roomed set of Cooly lines with double verandahs for Tamil coolies.
4. One Crepe Drying Shed at Factory Site.
5. One Concrete General Store and Tool Store.
6. One semi-permanent House for the Malay Telephone Operator.
7. One new Concrete Temple.

On instructions from the Tamil Inspector of Schools, an extension was made to the existing accommodation in the school.

The present office building was extended, an additional room being fitted as a small Pathological field laboratory.

All buildings and machinery are inspected regularly, are in good repair and are all fully covered by insurance.

28. Correspondence

A considerable amount of correspondence was dealt with during the year. Requests for estimates of work, and practical planting details were dealt with by this Division; letters requiring advisory information were passed to the Director for action.

29. History File and Cost Cards

These were kept up-to-date, and are available at the Station Office for visitors' inspection.

30. Staff

The staff employed at the Station comprises:—

Europeans	3
Non-Europeans	15

Europeans

H. W. Foston	Manager
T. N. Dickson	Assistant Manager
R. F. Harley	Assistant

Non-Europeans

Experiment Station Staff	*Institute Staff*
1 Clerk	5 Botanical Division Assistants
1 Assistant Clerk Typist	1 Soils Division Assistant
1 Dresser	2 Pathological Division „
1 Field Conductor	1 Asiatic Rubber Instructor
1 Tapping Conductor	
1 Factory Clerk	

The Asiatic Rubber Instructor assists in conducting Asiatic planters round the Station.

General

During the year a total of 725 people signed the Visitors' book at this office. Many directors of companies from London, Paris, Antwerp and Brussels and members of research organisations in Sumatra, Java and Ceylon, visited the Station.

Sir Frank Stockdale, Adviser on Agriculture to the Colonial Office, and Dr. Crowther of Rothamsted Experimental Station, visited the Station in February.

The following branches of the Incorporated Society of Planters and District Planters' Associations visited the Station, Central Pahang D.P.A., Kuala Selangor Branch I.S.P., Seremban-Rantau-Port Dickson Branch of the I.S.P., and a party of 85 members of the Estate Asiatic Staffs Association, Selangor.

The Vice-Chairman of the Burma Planters' Association and the local R.G.A. Member for Burma also visited the Station, and planters from India, Ceylon, Sumatra and Burma were taken round by the staff.

Monthly statements of expenditure are prepared and presented to the Director for scrutiny on his regular visits to the Station.

Mr. T. N. Dickson went on leave in April and returned from England in October. During Mr. Dickson's absence, Mr. E. A. Barron was temporarily engaged as Assistant.

I have again to record with appreciation the excellent work carried out by the staff during the year.

Our thanks are due to the General Manager, Kepong (Malay) Rubber Estates Ltd., for his assistance during our trials on the new Tunnel smoke-house, and this gentleman also assists us by permitting visitors to be taken round replanted areas belonging to his Company.

During the year lectures on "Replanting with Special Reference to the work being carried out on the Experiment Station" and "New Planting from Jungle" were given by Messrs. Foston and Dickson to the following District Planters' Associations and branches of the Incorporated Society of Planters.

Kuala Langat D.P.A. (Banting)	Replanting	H. W. Foston
Central Pahang D.P.A. (Bentong)	New Planting	„
Bahau Branch I.S.P. (Bahau)	New Planting	„
Rantau-Port Dickson I.S.P., (Rantau)	New Planting	„
Kajang Branch I.S.P. (Kajang)	Replanting	„
Taiping D.P.A. (Taiping)	New Planting	T. N. Dickson
Penang and Province Wellesley D.P.A.	Replanting	„

The work of felling and clearing Blocks 34 and 35 was carried out entirely by Malay labour. Excellent work was done by the 150 labourers employed. On completion of these works, these labourers were passed on to estates carrying out New Planting Schemes.

This type of labour excels at "Contour Felling" and an opportunity for Malays to take up this work is available at present, and this opportunity should not be missed by them.

Mr. Foston carried out a tour of experimental areas under the auspices of the R.R.I. in Kedah and Perak, and a similar tour was carried out by Mr. Dickson in Johore. Reports were submitted to the Director.

This will be the last report to be submitted by the writer, who in June 1939 leaves to take up advisory work with a local Agency firm.

The writer wishes to emphasise his indebtedness to the Board, the successive Directors under whom he has served, and to his brother Officers for the help and assistance so willingly given during the past 10 years.

H. W. Foston

Manager

Sungei Buloh

13th February, 1939

ANNUAL REPORT*

SMALL-HOLDERS' ADVISORY SERVICE

Supervision and Organisation

During 1938 the gradual expansion of the Small-holders' Advisory Service has been continued. The writer was appointed as Small-holders' Advisory Officer in March and commenced his duties in May. In company with the Personal Assistant to the Director (Mr. Moore) who, from his appointment as such, had been responsible for the supervision of this Service, tours to Negri Sembilan, Malacca, Johore, Province Wellesley, Penang, Kedah and Perak were carried out. The East Coast (Kelantan and North Trengganu) and Pahang were visited by the writer alone. Thus introductions to the Instructors and Supervising Officers in the various districts were completed.

The major tours carried out during the year are indicated in the following summary:—

State or Territory	Dates	No. of Asiatic Rubber Instructors visited	Remarks
Negri Sembilan, Malacca and Johore	10th—17th June	6	With Personal Assistant to Director
Pahang (East)	2nd—9th July	2	
Negri Sembilan and Malacca	2nd—6th August	3	Following visit to Muar Agricultural Show
Perak, Kedah, Penang & Province Wellesley	1st—10th September	8	With Personal Assistant to Director
Johore and Singapore	1st—14th October	6	
Pahang (except East)	1st—5th November	2	
Negri Sembilan and Malacca	18th—23rd December	4	
Selangor	various	4	Visited as opportunity occurred
Brunei and Labuan	10th—17th August	1	Visited by the Director

The report for the year 1937 is included in the Annual Report of the Directors' see pages 31-40 *Annual Report 1937*.

Distribution of Asiatic Rubber Instructors

(31st December, 1938)

State or Territory	Area of Small-holdings Acres	Asiatic Rubber Instructors				Average area of Small-holdings per A.R.I. acres
		Malay	Chinese	Indian	Total	
Perak ...	265,988	3	1	—	4	66,497
Selangor ...	143,710	2	1	1	4	35,927
Negri Sembilan	99,213	1	1	1	3	33,071
Pahang ...	80,708	3	—	—	3	26,902
Total F.M.S. ...	589,619	9	3	2	14	42,116
Malacca ...	67,680	1	—	—	1	67,680
Province Wellesley ...	23,384	1	—	—	1	38,664(1)
Penang ...	15,280	Served by A.R.I., P.W.				
Singapore ...	19,568	Possible service by A.R.Is,. Johore				
Labuan ...	1,825	Served by A.R.I. Brunei				
Total S.S. ...	127,737	2	—	—	2	53,172(2)
Johore ...	360,759	3	1	1	5	76,065(3)
Kedah ...	96,274	2	—	—	2	49,804
Perlis ...	3,334	Possible service by A.R.I., Kedah				
Kelantan ...	58,271	2	—	—	2	29,135
Trengganu ...	31,653	A.R.I. temporarily transferred to Kelantan				
Brunei ...	8,175	1	—	—	1	10,000(4)
Total U.M.S. ...	558,466	8	1	1	10	57,986(5)
Total MALAYA ...	1,275,822	19	4	3	26	49,070
R.R.I. Experiment Station	—	1	1	—	2	—
Leave ...	—	—	—	—	—	—
Total A.R.Is.	—	20	5	3	28	—

(1) including Penang
(2) omitting Singapore and Labuan
(3) including Singapore
(4) including Labuan
(5) including Singapore and Labuan

It is now possible for each Asiatic Rubber Instructor to be visited by the writer approximately once in four months, except those on the East Coast and in Brunei who, because of the time needed for travelling to those places, must be visited less often. This increase in personal contact between the Institute and its Asiatic Instructors has already had good results. For the purpose of supervision in the field each Asiatic Rubber Instructor is attached to the Agricultural Officer in charge of the District, State or Settlement in which he works. Our thanks are once again due to the Department of Agriculture and its officers for the invaluable help thus given.

Asiatic Rubber Instructors

In 1938, five new Asiatic Rubber Instructors (A.R.I.) were appointed—one Indian, previously a Laboratory Assistant in the Institute, and four Malays. Three of the latter came direct from the School of Agriculture, Malaya, while the other had formerly worked in the Department of Agriculture. All were given the usual intensive refresher course at Serdang and at the R.R.I. Experiment Station before taking up their stations in June.

We have to record with regret the loss of one Chinese Instructor who died during the year.

The figures (Ref. *Rubber Statistics Handbook,* 1938, p. 16) shown in the last column on page 193 are not strictly correct since many A.R.Is., particularly Chinese and Indian, often work on small estates over 100 acres in area. The effective average area per A.R.I. is therefore probably near 60,000 acres.

Asiatic Rubber Demonstrators

The major question of improving the quality of sheet produced requires numerous demonstrations on the proper use of acid and sieve. Improvement being normally slow, constant repetition is necessary. With this in view the Board, at a meeting held towards the end of 1937, approved the appointment of the first Asiatic Rubber Demonstrator (A.R.D.) for work in Kelantan, where the idea was originated by an A.R.I. and was supported by the State Agricultural Officer. A local Malay was appointed at a salary of approximately one-quarter that of the A.R.I. The scheme proved a distinct success, so was extended to a few other backward districts. At the end of 1938 the total number of Demonstrators was four. Two others were temporarily engaged, while one appointed in Johore proved unsuitable and was discharged. The distribution was as follows:—

State	District	Date appointed	Remarks
Kelantan	Kota Bharu	January, 1938	The first appointment
Trengganu ...	Besut	May	Temporarily only as A.R.I. was later transferred to Kelantan
Johore ...	Batu Pahat	June	Discharged in November
Selangor ...	Kuala Selangor	July	Temporary
Kelantan ...	Ulu Kelantan	July	
Pahang ...	Raub	November	
Selangor ...	Ulu Langat	December	

As the scope and effectiveness of the A.R.I. under whom the A.R.D. works appears to be very considerably increased, provision has been made for the employment of 12 Asiatic Rubber Demonstrators in 1939. In addition to this increase in scope, an A.R.I. who has an A.R.D. to relieve him of much routine demonstration work, can devote more time to the now highly important subjects of replanting and new planting.

A.R.I. at Experiment Station

The policy, adopted in April 1937, of always having an A.R.I. at the Experiment Station was continued during 1938. The Malay Instructor who was at the Station at the beginning of 1938 left on transfer to Trengganu in February and was followed by one of the Indian Instructors who remained until October, rather longer than the normal period of residence. The latter was replaced, on his transfer to Negri Sembilan, by a Malay from Kelantan who was still at the Station at the end of the year, being joined in November by a Chinese Instructor from Johore.

During the period the A.R.I. is at the Station he receives a thorough practical training, is useful in connection with sundry small-holding work for which no regular A.R.I. can be spared, and assists with Asiatic visitors to the Experiment Station. The experiment has been a continued success. The A.R.I.s. already trained have obviously benefitted and their efficiency as advisers to small-holders has definitely been increased.

Advisory Policy

The function of the Small-holders' Advisory Service is to give advice to small-holders on all aspects of rubber production. The general policy has in the past concentrated on providing advice which was inexpensive, easy to carry out and offered immediate and obvious results. It was therefore largely confined to sheet-rubber preparation. By this method the confidence of the small-holders in the A.R.Is. has been obtained, and many owners are now prepared to follow advice which may appear costly in both time and money without offering any apparent immediate beneficial results. The policy must therefore now cover new planting and replanting, particularly in those areas where existing bark conditions are poor owing to bad treatment in the past. It is probable that in 1939, with the new Regulations on both new planting and replanting in force, this change in policy will be more marked.

Propaganda and Marketing Committee

The Institute continued to be represented on the above Committee, on which are also representatives of the Co-operative Societies Department, the Department of Agriculture and the Veterinary Department. This serves a useful purpose in that the various activities of small-holders are discussed in proper relation to each other.

Preparation and Marketing of Rubber

The teaching of the correct method of sheet preparation has been continued during 1938 and in some of the more backward areas has been intensified by the appointment of Asiatic Rubber Demonstrators, as recorded above. In addition several new types of sieves suitable for use by small-holders were prepared and tried experimentally in the field. It is hoped that the type found to be best will be available for sale to small-holders in 1939, at a price well within their means. Without doubt, the present shortage of low-grade sheet, noted by several of the larger concerns exporting rubber from Malaya, is largely a result of the work of the Small-holders' Advisory Service. Striking results have been obtained in Kelantan and Trengganu. There, before the provision of A.R.Is. and Demonstrators, most of the rubber produced by small-holders was in the form of very dirty slab, often containing no more than 40 per cent of dry rubber, which required expensive re-milling before it could be exported. By the end of 1938 most of the rubber produced was in the form of sheet, with a consequently greater profit to the small-holder, and local remilling factories were having great difficulty in obtaining enough slab to keep them working.

It is, however, unfortunately true that in many other localities small-holders are discouraged from producing good smoked sheet by the low premium paid for it by the local kampong rubber-dealers. It is therefore apparent that improved methods of marketing are necessary. In this connection a physical grading scheme on an experimental scale was tried out in Kuala Selangor. Briefly the scheme was that the A.R.I. stationed in that district should visit one area three times per week and grade all the available rubber before the producers sold it to the local dealer. This was not a success, since the dealer was not prepared to accept the grades as selected by the A.R.I. and to pay accordingly.

Bulk selling to a larger dealer in Klang was next tried. The rubber produced by a group of small-holders was sold together with a greater profit to all. This method has since been tried on a larger scale by the Co-operative Societies Department with similar results, an increase in price of about $1 per picul usually being obtained. In some of the lots sold over 70 per cent of the rubber was classed as "Chinese Prime" by the buyers, thus again confirming that small-holders can produce good rubber under good marketing conditions.

The Price-Grading Scheme introduced in Pahang in 1935 has been continued there with fair success throughout the year. It is now being tried in Trengganu, Brunei, parts of Selangor, Perak, and Malacca, but results outside Pahang have been disappointing owing to the difficulty of securing the ready co-operation of the smaller rubber dealers.

Tapping

The most common systems of tapping approximate to a one-third spiral cut tapped daily, but cuts are frequently badly placed and may run in the wrong direction as often as in the right. Many holdings are, however, seriously overtapped, the total length of the cuts tapped daily on any one tree being sometimes greater than the tree's circumference. For some unknown reason, tapping of this sort has in one district been called "*potong american*" (*i.e.* the "American System").

Propaganda on the improvement of the general standard of tapping was continued throughout the year but without much success. The average small-holder still cares little for the rate at which his bark is consumed, which may be as high as three or four inches per month, and is quite unmoved by warnings as to what may happen in a few years' time if he continues to tap as wastefully as at present. In a few isolated cases owners have started to put monthly "chops" on the panels with good results, the rate of bark consumption being considerably reduced. In

most instances, however, even where the A.R.I. or A.R.D. has himself applied the "chops" on a sample number of trees for three or four consecutive months, the owners have shown little interest and have not themselves continued this practice.

On most holdings bad wounding is of general occurrence, resulting in poor renewing panels which would often be considered untappable on European planting standards. On the younger Chinese or Javanese-owned holdings, however, the actual knife work is often of a very high standard although, owing to the usual lack of monthly "chops" the rate of bark renewal cannot readily be accurately determined.

Treatment of Land and Soil

Most small-holders previously thought that if they allowed natural jungle plants to form a ground cover in their holdings, the assessment would be reduced. This difficulty has now been generally overcome and propaganda in favour of growing desirable natural covers has been continued with considerable success, aided no doubt by the fact that owing to the low prices obtained for rubber the small-holder could not afford to pay the labour for clean-weeding. Consequently many holdings now carry a flourishing cover of jungle plants. This is, however, often allowed to grow too high and too close to the trees, rendering them more liable to Mouldy Rot attack. In other instances the cover has been cut back too often and too low so that it has been weakened and *lalang* has managed to get a strong hold.

Physical methods of soil conservation are practised in only a few holdings, mainly those belonging to Chinese who prefer this method to the growing of covers, since many of them consider that covers on a holding indicate that the owner is so poor that he cannot keep his estate clean.

More interest is now being shown by small-holders in manuring, particularly by Chinese and Chettiars, and each A.R.I. has been supplied with sample bottles of the various manures most commonly used. On most Malay-owned holdings, owing to the high stand of trees and the consequent protection afforded to the soil, the need for manures is not so great.

Pests and Diseases

The most serious disease affecting small-holdings is still Mouldy Rot, which causes much damage throughout the country, particularly in those districts in which padi is not extensively grown. In the latter there is often less damage since most small-holders are busy planting padi during the wet season when the

disease is most virulent, and many holdings are therefore not tapped. The Department of Agriculture has however continued the policy of selling approved fungicides at cost price to small-holders, and A.R.Is. have helped in their distribution. In spite of this, tar and other unsuitable preparations continue to be used.

Owing to previous cultivation and the growth of "catch-crops" with the young rubber plants, root diseases are not generally such a serious problem as they are on many large estates. In some districts they do occur and are causing considerable damage but only in a few isolated instances are they being treated on the approved lines.

White Ants, however, are now being more generally treated, "Cymag" and sodium silico-fluoride being supplied in some States at cost price through the Department of Agriculture.

Replanting and New Planting

Towards the end of 1938 small-holders and the Asiatic owners of small estates have shown greater interest in the subjects of new planting and replanting. It was unfortunate that at the time when "share certificates" to cover new planting in 1939 were distributed, few small-holders, particularly Malays, fully understood their purpose. Consequently they readily sold them to the local rubber-dealers, receiving in many cases less than one dollar per Share (*i.e.* less than $20 per acre). Later when the new-planting rules were more widely understood, many regretted selling them and some even bought them back at a higher price.

Similarly in connection with replanting. The new regulations governing replanting after 1st January, 1939, have now been issued and when the small-holder understands that there will be no cut in his assessment for five years following that year in which he obtains permission to replant, but will continue to receive his "coupons," an enhanced interest may be shown.

The following summary of approved applications is of interest, and although many of the holdings included therein are not small-holdings in the strict sense (being small estates over 100 acres in area), it is probable that advice will be conveyed to the owners by the Small-holders' Advisory Service.

No definite data are available for the Unfederated States but considerable activity is apparent, particularly in Johore where the Indian Rubber Instructor, in his district alone, estimated that at the end of the year there would be more than 2,000 acres of new planting and replanting to be undertaken during 1939.

High-Yielding Planting Material for Small-holders

Any extension of the area planted with high-yielding selected material would, apart from the benefit accruing to the small-

Approved Applications for Replanting and New Planting on Small-holdings

Up to and including December, 1938.

	Chinese		Indian		Malay		Total	
	Area in acres	No. of Applications	Area in acres	No. of Applications	Area in acres	No. of Applications	Area in acres	No. of Applications
1. *Replanting*								
Selangor	446	15	80	5	34	4	580	24
Pahang	14	2	68	3	15	5	97	10
Perak	102	23	33	4	38	4	173	31
N. Sembilan	398	6	243	7	—	—	641	13
S. Settlements	177	5	194	6	11	2	382	13
	1,137	51	518	25	98	15	1,873	91
2. *New Planting*								
Selangor	87	6	—	—			87	6
Pahang	551	3	1,346	6			1,897	9
Perak	48	2	326	6			374	8
N. Sembilan	652	7	264	8			916	15
S. Settlements	63	3	22	1			85	4
	1,401	21	1,958	21	—	—	3,359	42
3. *Nurseries*								
Selangor	1.3	2	—	—			1.3	2
Pahang	3.3	5	—	—			3.3	5
Perak	—	—	3.0	1			3.0	1
N. Sembilan	9.8	3	3.5	6			13,3	9
S. Settlements	0.5	1	0.5	1			1.0	2
	14.9	11	7.0	8			21.9	19

holder himself, place Malaya in a stronger position in relation to other rubber-producing countries and this advantage would be reflected in the terms of any future International Rubber Regulation Agreements. It was, therefore, decided at a meeting held in the Institute on 15th September, 1938, that the Department of Agriculture would establish multiplication budwood nurseries at suitable selected Agricultural Stations throughout the country, the nucleus budwood for which would be supplied from the R.R.I. Experiment Station in the form of budded stumps. Subsequently approximately 600 stumps of each of the clones Tj. 1, Tj. 16, B.D. 5 and Avros 49 were prepared, these being considered the best of the non-proprietary clones at present available. Avros 50 will be added to the above for use in those localities for which B.D. 5 is unsuited.

By this means it is hoped that there will be an adequate cheap supply of good material available for use by small-holders in 1940, when it will first be required.

Under this heading it is interesting to note that in a recent official Dutch publication it was stated that F. 275,000 had been voted by the Administrators of the Rubber Fund in the Dutch East Indies for the purpose of establishing seed gardens in Palembang, Djambi, and West Borneo, in order to supply clonal seed of approved origin to native cultivators.

Shows

The Institute did not, as in 1937, send any travelling exhibits to Mukim or District Shows during the year. In all cases the exhibits were obtained locally and arranged by the A.R.Is. themselves, lectures and demonstrations in addition being in some instances given. Suitable descriptive labels in four languages were, however, sent to each A.R.I. in attendance at a show. Several of the shows were visited by officers of the Institute.

The Malayan Agri-Horticultural Association Show was held from 30th July to 1st August and as formerly the Institute assumed responsibility for arranging and judging the entries in the All-Malayan Small-holders' Rubber Competition, which formed part of the show. On account of the very high standard of sheet exhibited, the judges found it impossible on this occasion to differentiate between the first, second and third best exhibits. Subsequently seven equal prizes were awarded to the seven best exhibits, all of which were equally excellent and were classed as "supergrade."

Exhibits of interest to small-holders were on display, and A.R.Is. were on duty to explain them. The Institute was also open

to the public during the period of the M.A.H.A. Show, and many small-holders came.

Publications

Early in 1938 an illustrated Planting Manual (No. 7) was produced by the Institute specially for small-holders. It was first issued in English. Translations into Malay and Chinese have already been made and issued (by the Department of Agriculture) and a Tamil translation is being prepared. It is interesting to note that authorities in Burma and Siam have asked, and been given, permission to translate into their languages as much of the book as they wish. Copies of the Malay edition have been purchased by the Sarawak Government for use among small-holders there.

In addition, the principal illustrations in Manual No. 7, with titles in four languages, were printed in the form of posters for display in prominent places such as rubber-dealers' shops and "penghulus'" offices.

An article on practical budgrafting, originally published in *Ameasan* and not specifically intended for small-holders, has been issued as reprints to the A.R.Is. and is available for distribution to those Asiatic rubber growers to whom it is of use. Finally 50,000 leaflets in Jawi, with summary in English, have been printed giving quantitative directions for the use of formic acid and water in coagulating latex to make good sheet rubber. These are distributed amongst those attending demonstrations, and serve to emphasize the principal details.

Rural Lecture Caravan

As in previous years a caravan, jointly operated by the Department of Agriculture, the Co-operative Societies Department, F.M.S. & S.S. and the Rubber Research Institute, toured the rural districts. A.R.Is. attended the caravan when it visited their respective districts, giving lectures and demonstrations and providing commentaries to the lantern slides dealing with rubber cultivation.

The old caravan was wrecked early in 1938, and a lorry was fitted as a substitute and used for most of the year. A new caravan is being built and will be completed early in 1939.

Since suitable cinematograph films for the dissemination of propaganda on rubber and other agricultural crops are relatively expensive to prepare, and difficult to manipulate in such a manner as to demonstrate clearly points of detail, it was decided that still films be prepared from suitable Leica photographs to supplement the existing lantern slides.

Experimental Work—Ampang

The three small blocks replanted in 1937 have developed satisfactorily. In November 1938 a further small block of 1.3 acres was replanted, making a total of 4.5 acres over the two years. It is intended to replant similar small blocks almost every year, so as to have a series of demonstration areas covering all stages of development.

Following a careful tree-to-tree inspection for root disease, the old rubber trees in the 1938 replanted area were, in order to reduce initial expense, cut out at approximately three feet above ground level, the stumps continuing in tapping. Contour terraces were laid out by means of a wooden trestle and spirit-level, an instrument which can be cheaply constructed by small-holders. By such means it is hoped to reduce the heavy initial costs of replanting, as at present carried out on the larger estates, to a figure which will be within reach of the average small-holder.

These areas are serving a useful purpose as demonstration centres for visiting small-holders and Asiatic planters, many of whom are not yet convinced that successful replanting is practicable. The three areas replanted towards the end of November, 1937, were budgrafted in December, 1938, after the growth measurements which were being taken to observe shade effect had been completed for the year. One block has been budded with Tj 1, and one with Tj. 16. The third, opposite the Institute, which will be a museum block, was budded with Tj. 1, Tj. 16, Avros 49, Avros 50, B.D. 5, Pilmoor B. 84, G. 1, R.R.I. 500, 501, 506, 513 and 514 in small monoclone blocks of approximately 12 trees each.

A budding demonstration for local "penghulus," "ketuas" and small-holders was arranged whilst the above work was in progress, and was attended by over 80 people. Many of the visitors then proceeded to the Experiment Station at Sungei Buloh which, in addition, has been visited on several occasions during the past year by groups of small-holders accompanied by an A.R.I.

Bark-Survey on Small-holdings

It may be commonly observed in all parts of the country that bark conditions on small-holdings appear generally to be unsatisfactory. This is the result of years of neglect and bad tapping. On what seems to be a large proportion of the trees on many holdings, tapping at normal heights is no longer possible. In such cases there are only four things the owner can do. These are:—

(a) To stop trying to tap, and to live by selling his "coupons."

(b) To tap higher up the tree. This is often not profitable as labour costs more and the crop is reduced.
(c) To replant.
(d) To sell his land.

Alternatives (a) and (b) can only be temporary, and eventually every owner will be faced with the necessity for replanting the land. At present the Rubber Regulation rules offer what should be a strong inducement to replant, in that there will, for five years, be no reduction in assessment on land which has been replanted, but even so the amount of replanting on small-holdings is likely to fall far short of what is needed to replace uneconomic areas. It is feared that any small-holder who fails to replant will in time be driven to selling his land to some person or company who buys it for that purpose. Already many thousands of acres have changed hands in this way. The sellers rarely have the opportunity or initiative to invest the proceeds of the sale in new property. When their money is finished they are likely to migrate to the towns or to seek work as coolies—perhaps on the land which they formerly owned.

The seriousness of the tendency outlined above needs no emphasis. In order to obtain some idea of how rapidly it is likely to proceed during the near future—so that, if necessary, measures can be proposed to check it—a comprehensive survey of bark reserves on small-holdings has been started. This is a development, with the aid of recent statistical methods, from a survey carried out for the Department of Agriculture in 1931/32. Each Asiatic Rubber Instructor, will measure bark reserves, and make other related observations, on twenty holdings in his district, so that altogether over 500 holdings will be examined. The method of selection and randomisation of the holdings and of the sample trees therein was decided in consultation with the Statistician of the Institute, so that the full value of the results may be realised.

R. H. Meikle

Small-holders' Advisory Officer

Kuala Lumpur

17th February, 1939

ANNUAL REPORT

LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON AND MALAYA)

The Committee and Technical Sub-Committee held three meetings during the year. There were also two meetings of the Sub-Committee on Standardisation of Raw Rubber appointed in 1937.

Meetings of the Committee and Sub-Committee were attended by Mr. J. Wilson, Director of the British Rubber Producers' Research Association and Mr. M. W. Philpott, Chemist of the Rubber Research Scheme, Ceylon. Mr. G. de Silva, member of the Board of Management, Ceylon, and Mr. T. N. Dickson, Assistant Manager of the Experiment Station of the Rubber Research Institute, Malaya, inspected the work being carried out in the Committee's laboratories during their visits to this country on leave.

Finance

Contributions of £2,625 and £875 were received from the Rubber Research Institute and the Rubber Research Scheme respectively towards the cost of the work of the Committee during the year 1938. The expenditure incurred amounted to £3,786.8.6d., and after allowing for reserve for plant and for liabilities outstanding, there was an unexpended balance of £900 at 31st December, 1938.

Appointment of Staff in Ceylon and Malaya

At the request of the Board of Management steps were taken to select candidates to fill the vacant posts of Geneticist and Soils Chemist. Arrangements were made by the Committee for the officers appointed to these posts, Dr. C. E. Ford and Dr. L. A. Whelan, to receive special study courses at the Rothamsted Experimental Station before proceeding to Ceylon.

Mr. V. H. Wentworth, who was appointed by the Rubber Research Institute on the recommendation of the Committee to fill the vacant post of Chemist in Malaya received preliminary training for one month in the laboratories of the Imperial Institute.

Co-operation with other Organisations

The year under review has seen a considerable extension of research activities financed by rubber producing interests through the three National research units formed under the aegis of the International Rubber Regulation Committee, viz. the British Rubber Producers' Research Association (London); the Rubber Stichting (Amsterdam) and the Institut Francais du Caoutchouc (Paris).

The London Advisory Committee has had under consideration appropriate measures to extend their liaison activities so as to extend and strengthen the co-operation between the research institutes in the East whose main function is that of production research and the aforementioned National units who are charged to conduct consumption research. Details of the measures were left in abeyance pending the arrival in England of the Director of the Rubber Research Institute, Malaya, but it is anticipated that the London Advisory Committee will be able to contribute internationally towards the general co-ordination of rubber research.

In order that the staff in London should be familiar with practical conditions of rubber preparation on the plantations and become better acquainted with the research in regard thereto carried out in the East, arrangements were made by the Committee for Mr. W. S. Davey to make an extensive tour of Malaya, Ceylon and the Netherlands East Indies.

Mr. Martin, Superintendent of Rubber Investigations, continued to serve as a representative of the R.A.B.R.M. on the Joint Committee of that Association and of the British Electrical Research Association, dealing with the quality of ebonite. He also represented the Rubber Growers' Association on the Committees of the British Standards Institution appointed with a view to co-ordinating methods of testing rubber and latex, where he served as Chairman of the Latex Panel.

Conferences between Mr. Martin and Dr. van Rossem, Director of Research of Rubber Stichting, were held in the Research Laboratories at Delft and at the Imperial Institute, at which matters of common interest were discussed.

At the request of the British Rubber Producers' Research Association, Mr. Martin visited the Sisal Research Station at the Linen Research Institute at Lambeg to report on various proposals for the application of rubber to sisal.

Mr. Martin represented both the Committee and Rubber Research Institute, Malaya, at the International Rubber Technology Conference in London. He also acted as general reporter to the section of the Conference dealing with plantation subjects. Mr. H. C. Baker submitted a paper on the preparation and properties of halogen derivatives of rubber from latex. A large party from the Conference accepted the invitation to visit the rubber research laboratories, exhibition galleries and cinema at the Imperial Institute where they were entertained to tea by the Institute and the Committee.

Standardisation of Raw Rubber

As stated in the Report for 1937 a Sub-Committee was appointed last year to deal with this subject in view of the complaints received from manufacturers concerning the difficulties experienced by some

of them in obtaining uniform supplies of raw rubber suitable for their requirements.

During a discussion with the Director of the Rubber Research Institute, Malaya, on the request made by the Sub-Committee for a comprehensive programme of research to be undertaken in the East, he suggested that it would be desirable first to obtain a definite statement as to the requirements of consumers of different types of rubber.

The report received on an enquiry circulated by the R.A.B.R.M. indicated that there was practical unanimity among its members as to the desirability of a standard product and there was general agreement as to the properties in which improvement is necessary, viz. normally the rubber should be free from mechanical impurities and mould; it should be of uniform softness (two grades, one soft, and the other hard, but both uniform might be advantageous); the rate of vulcanisation should be uniform and the ageing should be good.

The representatives of manufacturers on the Sub-Committee also pointed out that the range of variation in quality of first grade rubber is at present extremely wide, e.g. it is possible to find rubber which will be badly undervulcanised under standard conditions, whereas other rubber will vulcanise so rapidly as to "set up" on the mixing rolls.

The above views were confirmed in general by the Crude Rubber Committee and the Rubber Division of the American Chemical Society; also American and British manufacturers pointed out that with the unavoidable use of rubber showing wide variation in quality, consumers have experienced a desire for rubber approximating as closely as possible to their individual convenience and this has led to different opinions regarding the desired standard of quality of rubber. A uniform grade of rubber could and would be adapted (by the main consumers at least) in a standardised routine manner by appropriate processing and compounding.

It was considered by the Sub-Committee that in the first instance steps should be taken to determine the procedure to be adopted for fixing the tolerances to be allowed for a standard rubber and it was agreed that in view of the complexity of the problem work should be concentrated initially on vulcanisation properties and on liability to scorch. A preliminary specification dealing with these problems was submitted by the representatives of manufacturers and arrangements made for the staffs of the Committee and of the R.A.B.R.M. to co-operate in the preparation of detailed methods of testing.

The Sub-Committee were impressed by the statement made to them by manufacturers that about 10% of first grade plantation rubber contained sand in such quantity as to make it unsuitable for use in tube manufacture and the possibility of preparing a scheme for the identification, by an official mark, of rubber from estates

adopting agreed standards of cleanliness was under examination at the close of the year.

Investigations

The development of tests for determining the quality of latex again formed an important feature of the work. In the experimental investigations special attention was devoted to an examination of the results given by the methods advocated by different laboratories, which, although similar in principle, varied in detail, and gave slightly different results, particularly as regards the determination of the dry rubber content of latex. As a result of subsequent discussion with research and trade organisations interested in the subject, a definite procedure was agreed for inclusion in the draft specification for latex testing which is being prepared by the British Standards Institution.

The long-range investigation commenced last year of the colloidal properties of latex, was continued and was concerned with determining the lines of attack most likely to give fundamental information concerning the phenomena which occur in the preparation and utilisation of latex. It was decided to concentrate in the first instance on the examination of the distribution of non-rubber substances in latex, i.e. the amounts dispersed in water and the amounts on the surface and inside the rubber globule, together with the effect on this distribution of the addition of various substances to the latex. Some difficulty was experienced in obtaining accurate results by the method of investigation proposed, but this was mostly overcome by the end of the year. The work is being continued.

A new development during the year in the investigation of dry rubber was the study commenced of the resistance to abrasion of raw rubber when vulcanised in a tyre-tread mix. This investigation was prompted by the widely published claims for the superiority in this respect of tyre-treads made from synthetic materials. Progress in this investigation is somewhat hampered by the lack of a generally accepted reliable laboratory test for abrasion, but a method of test has now been approved by the Committee and is being used to study different types of raw rubber.

The grants made in previous years by the Technical Research Committee of the Rubber Growers' Association for the investigations into the use of latex cement mixtures for flooring and for the incorporation of rubber in bitumen for highway surfacing, were continued by the British Rubber Producers' Research Association on taking over the work of that Committee. Since its inception in 1935 the work on the application of latex to flooring has been principally concerned with mixtures of latex and aluminous cement. These investigations have established the principles involved in designing mixtures and have given firms who are interested in the subject,

some of whom have had little previous experience with rubber, a basis for practical development.

Attention has recently been concentrated on the possibility of devising superior mixtures without aluminous cement but using materials giving a mixture setting within a few days, with a view to obtaining improved properties as regards reliability, colour, texture and mechanical properties. The results so far obtained are promising.

In addition the development of physical tests has been continued with a view to the production of a quality specification. Owing to the novel properties of latex cement mixtures and the absence of recognised tests, the work will take some time to complete.

The laboratory investigations on the effect of rubber on the properties of bitumen were continued and, in addition, three highway surfacing trials were made with different types of mixtures including one containing a high proportion of rubber. This mixture was particularly interesting because it was the first section of a continuous carpet coat of a definitely rubbery nature so far laid in this country. Unfortunately this mixture is not sufficiently cohesive and it is probable that a larger quantity of bitumen or a softer grade than that employed is desirable.

As in previous years, the staff in London co-operated with the chemists in the East in the examination of samples prepared in connection with experiments in Ceylon and Malaya. A list of the reports furnished on these investigations and on others initiated in the Committee's laboratories is given below. Further information as to the investigations completed and in progress during 1938 will be found in the technical appendix to this report.

Reports on Investigations forwarded to Ceylon and Malaya during 1938

Latex

Testing

Latex testing:— (1) Extraneous matter; (2) Tensile Strength of dried latex films

Notes on the sampling of latex.
Sampling of latex.

Colloidal properties

Colloidal phenomena associated with creaming.
Investigations on the colloidal properties of latex.

Colloidal properties of latex:— (a) Distribution of nitrogen; (b) Studies in repeated creaming

Storage

Storage of latices containing different amounts of ammonia.

Effect of storage on the properties of latex:—
(a) Latex from Ceylon
(b) Latex from Malaya preserved with amounts of ammonia.

Concentration

Latex creamed with Konniyaku meal.
Concentration of latex by evaporation.

Preservation

Special types of latex
Examination of miscellaneous samples of latex.

Chemical Derivatives

Bromination of latex.

Dry Rubber

Properties of rubber of importance in connection with competition from synthetic products:—
(a) Development of a suitable abrasion test.
(b) Effect of conditions of storage and accessory substances on the properties of rubber.
Purified rubber from Java
Smoked sheet from Indo-China
Chlorinated and brominated derivatives of rubber from latex.

PATENTS

In conjunction with the British Rubber Producers' Research Association, steps were taken to obtain English patents in connection with the inventions arising out of the work of the staffs in London and the East. As in previous years, the R.R.I., Malaya and the R.R.S. Ceylon were supplied with copies of specifications in respect of inventions relating to processes for the preparation or utilisation of raw rubber and latex likely to be of interest to them.

Specifications sealed during 1938

474,651 Concentration of latex by Creaming (communicated by the Rubber Research Institute of Malaya)
476,073 Stabilised Cream (communicated by the R.R.I. Malaya)
476,269 Brominated Rubber
476,743 Preparation of Chlorinated Rubber
484,712 Rubber and Cement Mixtures

Other Patents in force at December 31, 1938

395,774 Soft Rubber
395,775 Rubber Crumb
396,880 Rubber Crumb
428,100 Rubber and Road Tar Mixtures
433,303 Concentration of Latex—Surface Process
430,935 Creaming Latex with Seed Gum
450,222 Hemi-Cellulose Creaming Agent
465,226 Organic Liquid Addition to Latex
415,133 Organic Colloidal Addition to Latex

P. J. Burgess

Chairman

J. A. Nelson

Secretary

Imperial Institute

27th July, 1939

TECHNICAL APPENDIX

To the Annual Report of the

LONDON ADVISORY COMMITTEE

Latex

Specification and Testing

In the Technical Appendix to the Report for 1937 reference was made to the interest displayed by the Crude Rubber Committee of the U.S.A. and the British Standards Institution (representing growers, manufacturers and trade organisations) in the formulation of a specification for latex. During the year special attention has been given to the problems arising from criticisms of some of the tests recommended by the British Standards Institution. These problems have been chiefly concerned with methods of sampling, determination of dry rubber content and the evaluation of colour (greyness).

Sampling

Experience gained in the routine testing of latex has shown that the lack of a standardised method of sampling sometimes leads to the collection of unrepresentative samples, e.g. a sample of creamed latex was found to have a dry rubber content of approximately 26% and obviously was not a representative sample, since on standing it separated into two layers, a cream and skim, and further samples subsequently obtained from the same consignment had a dry rubber content of over 50 per cent.

The method of sampling at present recommended by the British Standards Institution involves a considerable expenditure of time and energy in rolling, shaking and stirring in order to obtain a uniform dispersion, and the work is generally carried out at the Docks under non-technical supervision.

Efforts have accordingly been made to find a simpler and more reliable method of sampling, and in this connection experiments have been carried out, in co-operation with representatives of the rubber trade, using a sampling tube similar to that described by Georgi, (*Malayan Agric. Journal* 1937, XXV p. 461, see also Murphy *Proc. Rubber Technology Conference* 1938 p. 151) for the sampling of palm oil. It consists of an iron tube about 1½″ diam. and of sufficient length to reach the bottom of a 50 gallon drum. The base of the tube consists of a weight attached to an iron cable by which the bottom of the tube may be opened or closed as required. Owing to

the space occupied by the base, the tube does not sample the lowest layer of latex, but its use was found to reduce considerably the liability to a large error in sampling. The results given by concentrated latices were not so reliable as those given by 38–40 per cent. latex and in both cases stirring was still necessary to ensure reliability.

A modified sampling tube of stainless steel was, therefore, designed having a conical orifice in the base which can be sealed by means of a stainless steel ball attached to a rod. The end is detachable enabling the tube to be cleaned easily after each sample is drawn and, as the bottom plate is comparatively thin, latex down to $\frac{1}{16}$" from the bottom of the drum is included in the sample. Experience with this tube has shown that whilst it is still necessary to stir the latex to some extent, the amount of stirring required is reduced, and its use does eliminate the possibility of obtaining totally unrepresentative samples.

Determination of Dry-rubber-content

The details of the method of determining dry rubber content tentatively put forward for criticism by the British Standards Institution were considered to be satisfactory because the determination could be carried out without expensive equipment (*e.g.* crepeing rolls) and because the detailed procedure agreed upon is a compromise between the extremes of the differences between different laboratories. The detailed method has now been criticised because (a) the values obtained represent a figure which is in excess of the caoutchouc hydrocarbon in latex by an amount equal to the non-rubber substances in the washed and sheeted coagulum, and although the pure hydrocarbon content of latex is an ideal which is difficult to obtain, an improvement in this direction might be obtained by greater dilution of the latex and the addition of a more dilute coagulant; (b) the conditions of the determination do not always lead to the complete coagulation of the latex in the form of a coherent clot, and there is frequently a milky serum which represents a loss of rubber particularly in the case of centrifuged latex when tested in the East soon after preparation. These two criticisms are to a certain extent self-contradictory, because the greater the dilution of the latex the more difficult it is to obtain a coherent clot. Experiments were carried out in co-operation with other laboratories in Great Britain and it was found that the British Standards Institution method did not always yield a completely clear serum and that better coagulation was obtained with less dilution of the latex and stronger acid. Experiments were also carried out by the Rubber Research Institute, Malaya, who confirmed that the British Standards Institution method gave milky serum with freshly-prepared centrifuged latex, but was satisfactory for other types of latex. Further dilution of the latex

gave a less coherent clot. As a consequence of these experiments the British Standards Institution decided to restrict its method of determining dry rubber content to 38 to 40 per cent. ammonia-preserved latex, and has not so far formulated a method of determining the dry rubber content of concentrated latex.

On the recommendation of one organisation experiments were made with sulphuric acid as a coagulant. The results obtained in London and in Malaya were higher than those given by acetic acid, and it was difficult to account for the difference merely by assuming more complete coagulation. The method at present preferred by the staff is one using somewhat stronger acetic acid than that at present recommended in the British Standards Institution method, but further experience is necessary with all types of latex before making a definite recommendation.

In order to obtain data as to the reliability of the determination of dry rubber content by the methods now employed in different laboratories a series of six samples was prepared by the Rubber Research Institute of Malaya and submitted by the Committee to various laboratories in America, Great Britain and the East with a view to obtaining information as to the tolerances which may be expected. Murphy (*Proc. Rubber Technology Conference* 1938, p. 151) has suggested tolerances of ± 0.15%, a figure which is considered to be excessive by the trade. The results obtained in the different laboratories were observed to be in fairly good agreement, but an analysis of the variation indicated that the tolerance suggested by Murphy is not too wide.

Colour of Latex

In the previous report (1937) it was stated that the colour standards for matching latex had been brought to the notice of the British Standards Institution and the Rubber Trade Association, and that it was anticipated that these standards would become available at a low cost, if reproduced in the form of cellulose colour cards.

The colour card consisting of nine shades has been used tentatively by the Rubber Trade Association and has been found useful in settling disputes, but the colour of latex is now generally satisfactory and the number of cases requiring arbitration is very small. The British Standards Institution has also adopted a modified form of colour card, at the same time pointing out that it is necessary to use a colorimeter for the accurate measurement of colour. During the year an opportunity occurred of measuring colours of a number of latices with an inexpensive colorimeter of the photoelectric cell type (Bolton and Williams), and the apparatus appeared to be suitable for the purpose. With the aid of the colour cards there should be little difficulty in making a rough classification of the colour of latex

on estates, at the Docks and by the trade, and if further refinement is required, laboratory tests can be carried out with a colorimeter to determine how the colour of a sample compares with known standards.

Quality

The main object of the latex investigations carried out in London is to maintain and improve, in co-operation with the research organisations in the East, the quality of preserved and concentrated latex. The examination of samples prepared in the East by different treatments and under different conditions is only of value in so far as there are available suitable tests to determine important differences in quality. The usual routine tests involve chiefly the determination of the broad outline of the chemical composition of different latex samples, *e.g.* dry rubber content, ammonia, foreign matter, etc. These tests are of importance, but they fail to indicate whether a sample which is not obviously defective is more suitable for any purpose than another of similar composition. Not only is it necessary to determine the amount of rubber, ammonia, coagulum, foreign matter etc. in a latex, but it is even more important to know how the physical properties of different latices are modified by stabilisers, compounding ingredients and coagulants. The interpretation of differences in physical properties in terms of industrial technique is not easy but is likely to improve with experience. The chief difficulty, however, with regard to the determination of the quality of latex is that although physical properties can be determined for a given set of conditions the information obtained is usually specific to these conditions. The results may be misleading if the conclusions drawn are applied to different combinations of stabiliser, compounding ingredients and coagulants. It is, therefore, necessary to seek tests of a general and fundamental character in order to evaluate the quality of latex.

In previous years attention was given to the development of a zinc oxide-stirring stability test which has proved useful, but while the test distinguishes between latices containing different amounts of natural stabilising agents it fails to indicate how these latices are likely to behave when subsequently treated by manufacturers with various stabilising and other ingredients. In addition it is now known that a low stability according to this test may be associated with a high stability under industrial conditions, *e.g.* purified latex and latex preserved with sodium pentachlorphenate are unstable according to the test but give better results than normal latex under many industrial conditions. In spite of these deficiencies the test is being used in the Committee's laboratories for the routine examination of the quality of latex until a better one is available, because it has been found useful by some users of latex and indicates differences

in quality not determined by other means. The conclusions drawn from the test are limited, however, to differences in stability under the conditions of the test used without specifying whether the differences would in general be favourable or otherwise.

Attempts have been made by some manufacturers to advise other tests for the quality of latex, and particulars of two new tests were published during the year (*Proc. Rubber Technology Conference*, 1938, pp. 111 and 151) and these tests are being studied in the laboratories. Enquiries have indicated that there is a difference of opinion regarding their merits, and in any case they only give partial information regarding quality, and should be supplemented by other tests.

In order to devise fundamental tests for the quality of latex it is considered necessary to study (1) the rubber globules (2) the aqueous serum, and (3) the boundary surface between the globules and the serum. As far as possible these three phases are receiving individual attention, but since they are partly inter-related, it is generally necessary to study combinations of phases and to estimate indirectly the functions of each. The rubber globules vary in size and contain not only caoutchouc which may vary in quality and affect the usefulness of the latex but also non-rubber substances. The aqueous serum contains non-rubber substances which can react with compounding ingredients and cause profound changes in the properties of latex as well as in the vulcanising and ageing properties of the dry rubber. The boundary between the rubber globules and the serum is the seat of colloidal phenomena such as stability, coagulation, viscosity, etc.

The investigations so far carried out are in their preliminary stages and do not completely cover the range of subjects which it is desired to investigate. Principal attention has been given to devising a direct method of studying the chemistry of the boundary of the rubber globules and aqueous serum, by determining the distribution of non-rubber substances between the rubber globules and the aqueous serum. The method devised is probably not so useful as a routine test for the quality of latex as for studying chemical changes at the surface of rubber globules. Information on the subject may lead to and must in any case precede the development of a sound routine test for quality.

The second approach has been through a study of the properties of dried latex films with a view to obtaining information concerning differences in the caoutchouc and the effect of serum substances. As explained in last year's report there are objections to the use of this method as a routine test for quality but the investigation has shown that the caoutchouc in ammoniated latex differs in quality from that in fresh latex and that there is an important relation between

serum substances and caoutchouc markedly affecting the mechanical properties of the rubber. The investigation indicates that it may be desirable to institute control tests, but much further information is required before attempting to devise a test of this nature.

The third method has consisted in a study of creaming chiefly because it is a colloidal phenomenon, easily studied, which should bear some relation to boundary conditions and the nature of the serum substances. All these investigations have yielded important information, but whereas the first two are likely to become more important as they proceed, the study of creaming phenomena indicates that variations are likely to be correlated with viscosity, which if necessary could be studied more directly. Details of the investigations are as follows :—

Distribution of non-Rubber Substances in Latex

It is generally accepted that the rubber globules in latex are surrounded by a protein sheath which largely determines the colloidal behaviour of the latex. Whether other substances such as lipins are also involved is not so well known. Experiments were carried out to determine the relation between the concentration of non-rubber substances in the aqueous serum phase of latex and on the rubber globule, attention being given chiefly to the nitrogen distribution.

The methods used involve the separation of latex into two fractions containing different concentrations of rubber. From the amount of non-rubber substance present in each fraction the amount present in the aqueous serum and that associated with the rubber can be calcuated. Three methods of separation were tried, *viz,* (1) centrifuging, (2) filtering, and (3) creaming.

It was shown that the centrifuging method of separation gives unreliable results, and the discrepancies were ascribed to the fact that the smaller globules in the skim have a greater surface area per unit of weight than those in the cream and are, therefore, associated with more nitrogenous substances per unit of weight. In order to obtain reliable results it is necessary to obtain rubber-free serum, and experiments on prolonged centrifuging were in progress at the end of the year.

Both filtering and creaming have the advantage over centrifuging that they yield skim free from rubber. Experiments were carried out in which latex was diluted and then filtered through battery jars or through Bechhold porcelain ultra-filters. Again irregular results were obtained for the amount of nitrogen associated with the rubber globules, and the values found were sometimes higher than the amount of nitrogen in coagulated rubber. The experiment showed that although a rubber-free serum could be obtained, a thin layer of reversible paste accumulated on the walls of the filtering medium and

this paste appeared to hinder the passage of some of the nitrogenous material.

The determination of the amount of nitrogen associated with the rubber globules by separating latex into two fractions by the addition of creaming agents has the disadvantage that the equilibrium of non-rubber substances may be disturbed by the creaming agent, but information on this point is being obtained by comparing the results of creaming experiments with those given by prolonged centrifuging. In the meantime experiments were carried out in which a range of dilutions of latex was creamed with methyl cellulose and the non-rubber substance distribution determined. The results were not wholly satisfactory as methyl cellulose required the presence of a surface-active material for efficient creaming. Latex contains naturally-occurring surface-active materials, but on dilution there was insufficient for a clear separation of cream and rubber-free skim. There was evidence, however, that reliable values could be obtained for the control of non-rubber substances associated with the rubber in 40 per cent latex and that dilution did not markedly reduce the amount of nitrogen, acetone-soluble material and fatty acids associated with the rubber.

As sodium alginate is a creaming agent which can be obtained in a reasonably pure condition free from nitrogen, and as it does not require the assistance of a surface active material, the investigation was continued with this creaming agent, the creaming process being repeated ten times so as to obtain a much greater dilution of the serum substances than in the previous experiment.

The results showed that the amount of nitrogen associated with the rubber in the case of this sample of latex was dependent upon the dilution of the latex in accordance with the following law $(Nr) = 0.128\ (Ns)\ 0.056$ where (Nr) is the concentration of nitrogen in and on the rubber globules and (Ns) is the concentration of nitrogen in the serum. The amount of nitrogen associated with the rubber globules of the original latex was shown to be 0.17%, and after creaming 10 times, which was equivalent to diluting the serum 1000 times the concentration was 0.13%. The crepe obtained from the latex which had been creamed 10 times contained 0.12% nitrogen. The dry rubber content of the purified latex was 45.24% and the total solid content 45.39%.

It is interesting that these preliminary data indicate that dilution of the latex has only a small effect on the amount of nitrogen associated with the rubber globules. Other investigations using glycol cellulose as a creaming agent have shown that the fixed nitrogen can be reduced by treatment with alkalies, enzymes etc. and the investigations are being continued in order to study more thoroughly

the chemistry of alterations on the surface of the rubber globules produced by different treatments.

Properties of Dried Films

The tensile strength of dried latex films has been used by some organisations as a test for determining the quality of latex, but as indicated in last year's report the values obtained are markedly dependent upon the period during which the films are stored in a dry atmosphere. Investigation of the subject has, however, been continued and extended because the results indicated the possibility of a chemical change in the caoutchouc, and because the effect of various factors on the tensile strength of dried films is of technical importance, and it is desirable to understand the principles involved in the formation of strong and weak films.

For this purpose dried latex films from ammonia-preserved latex and from the same latex after purification by creaming four times were stored in (1) air, (2) oxygen, and (3) nitrogen over sulphuric acid and over saturated aqueous solution of potassium chloride and then submitted to tensile strength, plasticity and solubility tests. The latter was included because of the possibility of a sol-gel transformation in the rubber which would account for any changes in tensile strength observed. After keeping for five months there was little difference in properties due to the effect of storing in either air, oxygen or nitrogen, but samples kept dry were stronger, less plastic and less soluble than those kept in a moist atmosphere, even though the latter were dried before testing The most interesting feature of the results is that the "whole" latex samples kept in a dry condition were three times as strong as those from purified latex, and that the latter was the least soluble. There is, therefore, no direct relation between tensile strength and solubility. Further experiments have indicated that materials with colloidal properties similar to serum substances markedly improve the strength of dried latex films, and evidence has been obtained concerning fundamental principles governing the formation of strong and weak films, but there are gaps in the information obtained and publication is undesirable at this stage.

In order to determine solubility, experiments were made on the separation of sol and gel fractions by Pummerer's method (Ber. 1928, *61*, 1583) using ethyl ether, but it was found more convenient to dissolve the rubber in a mixture of 100 parts of xylene and 20 parts of ethyl alcohol which gives low viscosity solutions and facilitates the separation and washing of the insoluble fraction by centrifuging. The method proved to be quick and accurate within 0.5 per cent, but the mixture is a better solvent for rubber than ethyl ether and the sol and gel fractions are not the same as those obtained by Pummerer. Whereas crepe from fresh latex was completely soluble and

sheet almostly completely soluble, crepe and dried films from ammonia-preserved latex contained over 20 per cent insoluble rubber and in special circumstances over 40 per cent. It is an obvious conclusion that the treatment of latex with ammonia has an important effect on the caoutchouc phase (*c.f.* Roberts *J.R.R.I.M.* 8, 2, 1938, 196). It is unlikely that ammonia in the concentration employed in preserved latex produces the maximum effect on caoutchouc or that it is the only substances to have an effect. The investigation is, therefore, being continued.

Creaming phenomena

It was shown last year that creaming agents cause a reversible clustering of rubber globules which, on account of their size, rise more quickly towards the surface of the latex. The clustering effect is brought about by small concentrations of the creaming agent and is not markedly enhanced by higher concentrations. An obviously important factor in creaming is the viscosity of the aqueous serum which tends to retard the upward drift of the clusters. As all creaming agents form viscous solutions at low concentrations and the viscosity of the solution increases rapidly with concentration, it is obvious that there is an optimum concentration of creaming agent beyond which the increase in viscosity is more effective in retarding creaming than is the small increase in clustering in promoting creaming. In order to study the effect of viscosity on creaming, experiments were carried out with sodium alginate which has the advantage of being marketed in grades differing only in viscosity. It was found that the efficiency of creaming as measured by the relative amounts of rubber in the upper and lower layers, is a function of the viscosity of the underlayer, and does not depend upon the grade of creaming agent. Since the viscosity of the underlayer is an inverse function of the concentration of creaming agent, it is obvious that less of the more viscous grade is required to produce a particular degree of separation. The results also shew that creams with the highest dry rubber content are obtained at relatively low viscosities of the underlayer, the amount of creaming agent being insufficient to yield a skim free from rubber. Addition of more creaming agents enables a rubber-free skim to be obtained but the increase in viscosity retards the upward drift of rubber globules and consequently a cream with a lower dry rubber content is obtained in a normal period. Experiments were carried out with several other creaming agents differing in chemical constitution and viscosity, and the results also indicated that there is an optimum viscosity above and below which normal creaming agents are not so efficient. The results are not sufficiently extensive to draw definite conclusions, but it appears likely that an important control test on any creaming agent which

may vary in quality is to determine the viscosity of its aqueous solution and then to make an adjustment in the amount added to latex according to whether its viscosity is below or above the fixed standard.

Experience gained with methyl cellulose in the purification of ammonia-preserved latex by repeated creaming showed that this substance was exceptional in requiring the presence of surface-active materials (Twiss and Carpenter *Proc. Rubber Tech. Conference, 1938*). When latex which had been purified by creaming five times was treated with methyl cellulose, no clustering could be observed and the latex did not cream. Further experiments showed that both kationic and anionic soaps promoted clustering and, therefore, creaming with methyl cellulose in purified latex, and that the effect was independent of the pH of the latex over the range 3 to 12. It is remarkable that, although methyl cellulose requires a surface-active material to cause clustering and creaming, neither the chemical nature of the rubber globule nor the sign of the electric charge appears to be important.

The possibility has been considered that all creaming agents require a surface active material and that some of the creaming agents used are efficient with purified latex because they are of vegetable origin and are not necessarily pure substances but possibly mixtures of surface active material and clustering agent, but it was found that an ammonium salt of a high molecular polycarboxylic acid and sodium alginate were both able to cluster and cream purified latex in which methyl cellulose was inactive. It is evident, therefore, that additional surface-active materials are not essential to all creaming agents. The work on the mechanism of creaming is now being discontinued except in so far as it is related to other work on the chemistry of the surface of rubber globules.

Keeping Properties

No comprehensive study has yet been made of changes in the properties of preserved and concentrated latex on keeping and such an investigation cannot be carried out satisfactorily until methods of determining quality are available. Reference was made last year to the decrease in stability on keeping as determined by the zinc oxide-stirring test, and it has now been confirmed that according to this test preserved field latex with a high stability when first received in London becomes less stable after 12 months. The same latex concentrated by creaming is less stable than the unconcentrated latex on arrival in London, but after keeping 12 months the difference between the two is small. Evidence was also obtained that the 40 per cent latex has less nitrogen associated with the rubber globules after keeping and that the creamed latex shows little change, suggesting that the protein sheath around the rubber globules in normal

latex is slowly hydrolysed by ammonia, but that the creaming agent has hindered this reaction in the concentrated latex. It is not known whether these changes are specific to these samples or whether they represent a characteristic difference between creamed and normal latex. It is evident that the changes which occur are complex and require detailed study before drawing conclusions.

There is a slight tendency for the rubber content to decrease, presumably due to the formation of a few minute clots of coagulum when the latex comes into contact with both air and the container. There is, however, no obvious change in ammonia content. The investigation is being continued as opportunity occurs, but as explained above it is probably premature to arrange a systematic and comprehensive study at this stage.

Dry Rubber

Standard Rubber

In view of the representations of manufacturers, the Committee decided that special attention should be given to the preparation of uniform rubber on estates. This decision has raised a number of technical problems requiring action in the East and in London. The chief technical problems now being dealt with in London in this connection are (1) the formulation of standard methods of testing in co-operation with European and American manufacturers, (2) the critical consideration of standards of uniformity suggested by manufacturers, and (3) the carrying out of comparative tests in order to ensure that the same results can be obtained in different laboratories when testing duplicate samples.

At the end of the year the methods of testing to be employed had been outlined by manufacturers, and in co-operation with the Research Association of British Rubber Manufacturers, the staff had prepared a detailed specification. It will, however, probably require considerable revision before it receives wide circulation.

Criticisms of the proposed standards of uniformity have been received from the East, but no action has yet been taken because these standards must depend upon the methods of testing which are not yet fully approved, and it is necessary to accumulate as much data as possible using these specific methods before final decisions can be made regarding the standards of uniformity.

In the meantime tests have been carried out in co-operation with a manufacturer who supplied 12 samples with a range of properties beyond the limits of the provisional standards. Parallel results were obtained in the two laboratories, but there were regular differences which would affect the classification of the samples.

Further work is in progress in co-operation with the Research Association of British Rubber Manufacturers in order to determine causes of differences and to ensure if possible that two different laboratories carrying out the methods of test prescribed can obtain the same results within a reasonable and known margin of error.

Abrasion Resistance

The claim is made that some of the synthetic rubber-like materials are more resistant to abrasion than natural rubber and that tyres made of these new materials have a longer life than those hitherto manufactured. The relation between resistance to abrasion and chemical constitution is not known, but evidence continues to accumulate that the rubber hydrocarbon is not a material of fixed chemical constitution and that materials and conditions, which were previously regarded as inert, produce changes. Since some synthetic materials are apparently more resistant to abrasion than rubber, modifications of the chemical structure of rubber without destroying its normal mechanical and vulcanising properties may have some effect on its resistance to abrasion. Moreover, resistance to abrasion is markedly dependent upon the intimate relation between carbon black and rubber. This relationship is not fully understood, but there is sufficient information to indicate that alterations in the serum substances or in the rubber hydrocarbon may affect this relationship. Some rubber manufacturers consider that they have definite evidence of variation in resistance to abrasion due to variation in the rubber.

Taking these factors into account, there is a reasonable possibility that a systematic study of the problem may indicate methods of improving the resistance to abrasion of natural rubber. The chief difficulty is that abrasion tests are complicated and the results are not always consistent with those given in service.

After consultation with manufacturers it was decided to commence experiments using an Akron Standard Mould abrasion machine and a carbon black-rubber mix similar to those employed in tyre treads. These mixes are sometimes described as "sticky," the abraded particles clinging to the surface and affecting the results of abrasion tests. In preliminary experiments it was found that some samples of rubber prepared in the East by special methods were markedly superior to normal estate sheet, and manufacturers suggested that this result might be due to the stickiness of the mixture. Experiments have, therefore, been carried out to eliminate the possibility of misleading results due to this cause. The apparatus is now supplied with a grit feed which supplies carborundum powder between the sample and the abrasion wheel. More regular results are obtained, but the test is not yet regarded as wholly satisfactory and the investigation is being continued.

Halogen Derivatives of Rubber from Latex

A study has been made of the halogenation (chlorination and bromination) of rubber in latex because (1) fully chlorinated rubber prepared from rubber dispersed in an organic solvent is of technical importance and it may be possible to manufacture a cheaper or better product from latex, and (2), the modification of rubber by partial halogenation, without destroying completely vulcanising and elastic properties, may render it more suitable for special purposes. The investigation initiated in London and described in last year's report was continued by the Rubber Research Institute, in Malaya using fresh latex and the samples prepared were examined in London. The more heavily chlorinated samples were almost resinous and appeared to deteriorate on keeping, but those containing antioxidants still retained elastic properties. The brominated samples were superior to those containing chlorine. On vulcanisation the samples were inferior to standard rubber, but were more resistant to the swelling action of solvents. On the other hand they became very tender on immersion in solvents. The samples yielded ebonite with a higher softening point than that of ebonite from standard rubber, but the improvement in this direction was offset by an increase in brittleness. It was considered that the samples had no commercial value.

It was found that rubber in latex could not be chlorinated to the same degree as rubber in solution, but that in some circumstances chlorinated rubber in the form of a white powder very soluble in organic solvents could be obtained by keeping the temperature of the reaction below 50°C. The investigation is now being continued in the East with a view to determining whether a product with commercial applications can be obtained by the chlorination of fresh latex.

A study was made of the chemistry of the reaction between bromine and rubber in dilute latex by determining the amount of bromine which combined with the rubber and the amount of hydrobromic acid liberated and then calculating the amount added and substituted per isoprene unit. It was found that substitution and addition occurred simultaneously and that the addition was succeeded by cyclisation with the liberation of hydrobromic acid, the phenomenon being accelerated by factors (such as temperature and concentration of bromine) which increased the rate of reaction. As cyclisation represents a modification of rubber structure which would be expected to reduce elasticity, further experiments are proposed to study the properties of halogenated rubber prepared under conditions in which cyclisation is reduced as much as possible.

Application of Latex to Road or Floor Surfacing

Since its inception in 1935 the investigation on the application of latex to flooring (and road surfacing) has been principally

concerned with mixtures of latex and aluminous cement. During this period the manufacture of these materials has expanded considerably in Great Britain and interest in the subject is now being displayed in Australia and the U.S.A. The investigations carried out have established the principles involved in designing mixtures and have given firms who are interested in the subject (some of whom have had little previous experience with rubber) a basis for practical development. Further improvements are chiefly a question of detail, and as this type of investigation is best carried out by firms who are intimately associated with the practical problems of the trade, no further work on latex-aluminous cement mixtures was carried out in this direction during the year except to give attention to two problems which are within the scope of useful work better carried out by a central organisation. One of the problems is concerned with methods of determining the quality of the finished product and has been referred to in previous reports and the other with the variability of latex.

In addition attention was given to the possibility of devising entirely new mixtures without aluminous cement, but utilising the information previously obtained concerning the relation between microstructure and mechanical properties of latex-cement mixtures.

Quality of Finished Product

As indicated in last year's report it is desirable to devise methods of determining the quality of the finished latex-cement mixtures. A sound specification would eventually be helpful to experienced manufacturers and would give potential users greater confidence in the new materials. Manufacturers may regard a quality specification as premature but the development of methods of test and the collection of data take several years. In continuation of previous work on compression, indentation, restitution and water absorption special attention was given this year to the accurate determination of tensile strength and of the adhesion of the mixtures to wood, cement, metal, tiles, etc. In both cases improved tests were devised.

Latex Variation

Several firms in Great Britain have kept in touch with the Committee's investigations and conversations with technical staffs indicated that occasional difficulties are experienced owing to variability. An important part of this variation is due to the latex and an investigation was, therefore, commenced in which a study was made of the stability of compounded latex by several methods including the coagulation of the latex by aluminous cement. The investigation has not been carried sufficiently far to indicate a remedy

for the difficulties experienced, but it has shown that the stability of some compounded latices changes considerably on keeping even for a few days, and that a useful purpose would be served by determining the types of mixtures which are least affected by time. Alkaline materials such as sodium silicate or caustic potash are found to be responsible for the most rapid changes in properties, and latex preserved with sodium pentachlorphenate instead of ammonia appears to be the most stable to cement and the least affected by time. These investigations were still in progress at the end of the year.

New Mixtures

Aluminous cement-latex mixtures are mechanically superior to those made with Portland cement and the principal structural difference appears to be that the former contains much more colloidal matter than the latter. Attention was, therefore, given to a study of the effect of colloidal compounding ingredients on latex, and an increase of 75% in the energy required to break dried latex films was obtained in some cases. Processes of obtaining improved toughened mixtures from latex were devised without using aluminous cement by keeping in mind the importance of developing a colloidal structure within the finished product. These mixtures appear to be suitable for flooring and other purposes but the details require elaboration before the mixtures can be regarded as ready for commercial use.

G. Martin

Superintendent of Rubber Investigations

P. J. Burgess

Chairman

19th June, 1939

Publications

Publications of the Rubber Research Institute are issued in the following forms at prices stated at time of publication:

(a) **Planting Manuals**—being articles of an instructional nature primarily for estates' use. These appear at irregular intervals.

(b) **Bulletins**—being articles of special scientific interest printed and bound separately, appearing occasionally

(c) **Journal**—being articles by officers of the Institute on current work, appearing at irregular intervals as information accumulates during the year

(d) **Annual Reports** of the work of each Division during each year, with a summary by the Director R.R.I.

(e) **Information Cards**—being concise precis of the processes of estate factory practice.

(f) **R.R.I. Planters' Bulletin**—being articles and notes in non-technical language on matters of current interest to rubber planters, appearing every few weeks.

The following publications have been issued and copies can be obtained on application at the prices given against each :—

(a) PLANTING MANUALS

No. 1 "Guide to the Preparation of Plantation Rubber"
by B. J. Eaton (published August 1928) ... $2.00

No. 2 "Budding of Hevea in Modern Plantation Practice"
by F. Summers (published September 1928) (out of print)

No. 3 "Plantation Sheet Rubber Manufacture"
by R. O. Bishop (published February 1932) ... $2.00

No. 4 "Latex Preservation and Shipment"
by R. O. Bishop and R. G. Fullerton
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No. 5 "The History and Description of Clones of Hevea Brasiliensis"
by C. E. T. Mann and C. C. T. Sharp
(published August 1933) (out of print)
Stiff cover for filing the leaflets ... $0.50

No. 6 "The Uses and Control of Natural Undergrowth on Rubber Estates"
by W. B. Haines (published July 1934) (out of print)
Binder cover for filing the Manual ... $0.50

No. 7 "Rubber-Growing—Elementary Principles and Practice" (published February 1938) ... $0.50

(b) BULLETINS

No. 1 "Natural Coagulation of Hevea Latex"
by A. S. Corbet (published September 1929) (out of print)

No. 2 "A Study of the Effect of Damp Storage on Raw Rubber"
by B. J. Eaton and R. G. Fullerton
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No. 3 "The Root Disease Problem on Old Rubber Areas in Malaya"
by A. Sharples and A. R. Sanderson
(published November 1931) ... $1.00

No. 4 "A Summary of Meteorological Records, Soils Division"
by W. B. Haines (published December 1931) ... $1.00

No. 5 "Variations in the Composition of Latex from Clone and Seedling Rubber"
by J. L. Wiltshire (published July 1934) ... $1.00

(c) JOURNAL OF THE R.R.I.

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Edited by H. J. Page on behalf of the Board of the Rubber Research Institute of Malaya.